

# Comparing religious environmental ethics to support efforts to achieve local and global sustainability: empirical insights based on a theoretical framework

Fabio Zagonari

Dipartimento di Scienze Economiche, Università di Bologna, via Angherà 22, 47900 Rimini (Italy)

Phone: 0039 0541 434135 Fax: 0039 0541 434120 Email: [fabio.zagonari@unibo.it](mailto:fabio.zagonari@unibo.it)

ORCID: 0000-0002-9872-8731

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## Abstract

This paper develops a *theoretical* framework to assess the feasibility of environmental sustainability solutions, at local and global levels, based on the religious environmental ethics of several key religions: Hinduism (including Jainism), Buddhism (including Confucianism and Daoism), Judaism, Christianity (Catholicism, Eastern Orthodoxy, Protestantism), and Islam. Solutions are defined in terms of consumption (measured by GDP), environment use (measured by the ecological footprint), and welfare for representative individuals. *Empirical* insights for alternative religious environmental ethics focus on the relative importance attached to consumption of goods ( $\alpha$ ) vs. involvement in a (local/global) community, and on the importance attached to the environment within the (local/global) community ( $\mu$ ). In terms of *feasibility* for national environmental problems (i.e., pairs of  $\alpha$  and  $\mu$  achieving sustainability, in countries where the religion is a majority) and *consistency* (i.e., coherence with the religion's precepts) of policies for national environmental problems: Hinduism=Buddhism>Islam>Judaism. Christianity produced no feasible solutions. In terms of *effectiveness* for global environmental problems (i.e., pairs of  $\alpha$  and  $\mu$  achieving global sustainability, if inequalities among nations are reduced in the future) and *replicability* for local environmental problems (i.e., pairs of  $\alpha$  and  $\mu$  achieving sustainability in countries where the religion is a minority): Hinduism=Buddhism>Judaism>Islam.

## Keywords

Environmental ethics, religion, sustainability

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# 1. Introduction

Many sustainability concepts have been suggested in the literature (Zagonari, 2016a). To develop and calibrate a sustainability model at a national level, I will refer to the ecological footprint produced by consumption activities (EF), and will therefore measure sustainability as the direct and indirect per capita use of the environment by representative individuals. Here, I define EF as the area of land (ha) that is required to sustain one human life based on current ecological and consumption conditions.

Achieving sustainability might require technological improvements and value changes (Zagonari, 2016b), although changes in consumption patterns or in perceived responsibilities to nature, to the current generation, and to future generations, either separately or combined, might lead to insufficient or unfeasible solutions (Zagonari, 2018).

Many cultural factors explain the prevailing ethics that affect these perceived responsibilities at a national level (Zagonari, 2015). Here, I will refer to religious ethics, and I will represent sustainability conditions in terms of the main characteristics of several main religions. To avoid an arbitrary choice of religions, I have chosen religions whose members comprise at least 20% of the global population that has declared a religious affiliation. Although Judaism does not meet this criterion, I have included it for two main reasons. First, Judaism can be formalized as an approach to sustainability (i.e., to maximize the welfares of both current and future generations subject to a sustainable use of resources) that lies between the a-growth paradigm (i.e., to maximize the current generation's welfare subject to a sustainable use of resources) and the strong sustainability paradigm (i.e., to maximize the welfares of both current and future generations subject to an inter-generational equity in the use of resources) (Zagonari, 2018). Second, Judaism seems to represent a sustainability approach that is closest to the lifestyles currently prevailing in Western countries and that is increasingly being adopted by other countries (Mathevet et al., 2018).

The purpose of this paper is to develop a model of the impact on sustainability of the main religious environmental ethics within a single framework that accounts for changes in the relative importance attached to consumption from using the environment vs. perceiving the environment as a form of bonding social capital (Christoforou, 2013; i.e., the instrumental value for meeting human needs vs. the intrinsic value of nature). I will also account for anthropocentric vs. biocentric approaches (i.e., the relative moral status of both human and non-human life and the "dignity" of the environment; Maintenay, 2011), for intra- vs. inter-generational equity (i.e., fair distribution of uses of the environment, of welfare, or of consumption goods between present and future generations), for population dynamics, and for the perceived needs of humans in terms of consumption goods, welfare, or use of the environment. In this analysis, I have three main goals:

1. to *empirically* assess the feasibility of sustainability solutions that depend on religious environmental ethics at a national level (e.g., can Muslim countries achieve sustainability by relying on Islamic environmental ethics, despite the current unsustainable status?);
2. to *theoretically* discuss the consistency of the required emphasis on some aspects of the environmental ethics with the need to achieve sustainability (e.g., can Buddhist countries rely on an increased importance attached to the environment as a form of bonding social capital or rely on the dignity of non-humans, such as whether the lives of animals have value, to achieve sustainability if the importance attached to consumption increases?); and
3. to *empirically* assess the effectiveness of alternative religious environmental ethics for achieving sustainability solutions at a global level (e.g., which set of religious environmental ethical principles is most likely to achieve global sustainability if countries converge on a similarly unsustainable status?).

Note that considering religious rather than secular environmental ethics amounts to moving from suggestions to prescriptions and proscriptions. Moreover, I have consulted original religious texts such as the Hindu *Veda*, *Purana*, and *Mahabarata*, the Buddhist *Tipitaka*, the Jewish *Old Testament*, the Christian *New Testament*, and the Islamic *Qur'an* in order to identify clear and incontestable readings that describe the sources of a religion's environmental ethics. Needless to

say, the interpretation of Genesis 1 and 2 is based on the Cartesian disjunction between the human and natural worlds (Simkins, 2016), and I have adopted this interpretation for two main reasons. First, this disjunction lets us distinguish Judaism, with reference to Genesis 2 (i.e., humans as “stewards” for future generations), from Christianity, with reference to Genesis 1 (i.e., humans as “dominators” or “masters” over other forms of life), which in turn lets us statistically test the statement by White (1967) that “Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects”, based on humans as separated from nature, humans created in the image of God, and humans as dominant over nature. Second, this disjunction lets us distinguish concepts such as the rights of current and future generations from the rights of non-humans (Shoreman-Ouimet and Kopnina, 2015), intra- and intergenerational egalitarianism from interspecies egalitarianism (i.e., whether Earth’s resources should be proportionally or equally split between humans and non-humans) (Kopnina, 2016), and human altruism from biospheric altruism (altruism focused on humans from altruism focused on the biosphere) (Kopnina et al., 2018). We can then properly apply only the former concepts (i.e., rights of current and future generations, intra- and intergenerational egalitarianism, and human altruism) to achieve global sustainability, whereas the latter concepts (i.e., rights of non-humans, interspecies egalitarianism, and biospheric altruism) can be suitably combined in the intrinsic value of nature and in the perceived human responsibilities or duties to the rest of nature (Zagonari, 2018). In consulting the primary texts myself in search of the main relevant principles, I hope to avoid the disputable relative status of subsequent religious sources for the different religions as well as debate over the relative grade of alternative exegetic interpretations of the same environmental ethics in different versions of a sacred text (Jenkins, 2009). To limit the scope of the analysis, I have not included an analysis for the indigenous religions of Africa and other parts of the world because these religions are based on oral traditions and provide no canonical texts that can be used as the original source of inferred parameter values. Finally, considering religious principles rather than environmental practices lets me avoid rankings of secular environmental policies at a national level by focusing on attitude changes based on each religion’s sacred texts.

In particular, I will provide analytical and numerical solutions that characterise the main sets of religious environmental ethics, moving from an extreme individual perspective (i.e., that the environment should be preserved in order to achieve the largest possible consumption for individuals in current and future generations) to an extreme communal perspective (i.e., that the environment should be preserved because people receive happiness from being members of a local or global environmental community). Moreover, the analysis is based on the following specifications:

- *Efficiency* (i.e., the maximum output for a given use of the environment or the minimum use of the environment for a given output) is taken as a given, and is measured based on current technology rather than based on technological extrapolation. However, I will also explore the implications of improved technology that mitigates the impact on the environment.
- *Equity* (here, a fair distribution of something) applies to both current and future humans, but not to non-human life. Note that equity can become a sustainability *solution* if it is applied to both current and future generations, but it is a *problem* that can prevent sustainability if it is applied only to the current generation (i.e., there is no global sustainability problem if all countries, apart from the United States, consume at per capita rates like those of Bangladesh, but a global sustainability problem arises if all countries attempt to consume at per capita rates like those of the United States).
- *Justice* (i.e., positive or negative rights to something) applies to current humans, but not to future humans or to non-human beings, although I consider a sense of duty towards future generations or the environment and a sense of the dignity of non-human lives (i.e., different rights imply different perceived dignity, but not vice-versa).

Finally, I will develop analytical and numerical solutions that depend on current and future population sizes and perceived needs, both in terms of (current) welfare and in terms of (current) use of the environment, because these parameters are likely to change in time and space.

Note that my formalisations let us identify which aspects are shared by which religions. For example, Catholicism recently extended the dignity of the humans to the rest of creation, which seems to move Catholicism towards Hindu prescriptions. Moreover, seeking a universalist approach (i.e., the same approach for everyone) would postpone cooperative action until there is consensus on the worldview, whereas an approach based on each religion's code of ethics can be supported and implemented at a community level, with each religion relying on its own principles in the absence of a global consensus (Lai, 2011). Finally, my formalisation enables us to distinguish similar aspects of some religious ethics. For example, the imperfect and created sacred nature that is defined in Judaism can be depicted by the *small* importance attached to the environment as a form of bonding social capital, whereas the perfect and uncreated sacred nature that is defined in Buddhism can be depicted by an extension of the *same* dignity to human and non-human beings.

In summary, the main contribution of this paper is the representation of the main religious environmental ethics within *a single mathematical framework* and based on *measurable variables*, to allow both numerical and statistical analyses that will compare the feasibility, effectiveness, and replicability of different religious environmental ethics in the context of efforts to achieve local and global sustainability in similar contexts (e.g., if a more equal income distribution is achieved in the future) or alternative contexts (e.g., pre-industrial, industrial, or post-industrial economies). Note that the purpose of a *mathematical* approach is to make the analysis more objective once the underlying subjective assumptions have been clearly defined, thereby allowing future researchers to modify the assumptions if they want to explore what changes. Moreover, an *overall* mathematical framework permits objective comparisons, and it can subsequently be expanded in future research to compare different schools of thought within a religion or different cultures. Finally, the purpose of *quantification* is to improve the objectivity of an analysis, thereby revealing new insights by harnessing the power of mathematics and statistics to detect key factors or processes that might otherwise be missed.

## 2. The theoretical framework

In this section, I will characterise the main religious environmental ethics. All alternative religious environmental ethics considered in this study will use the following welfare function ( $W_i$ ) for a representative individual  $i$ :

$$W_i[X_i(E_i), Y_i(E_i)] = X_i^\alpha Y_i^\nu$$

A Cobb-Douglas (CD) utility function where  $X_i$  depicts the consumption of goods,  $E_i$  represents the use of the environment,  $Y_i$  depicts the involvement in the individual's community,  $\alpha$  represents the importance attached to consumption, and  $\nu$  represents the importance attached to the community. I use EF as the measure of  $E$ . Moreover, since this analysis focuses on the impacts on and from the environment,  $X$  is positively correlated with  $E$  (i.e., a larger consumption requires a larger use of the environment) and  $Y$  is negatively correlated with  $E$  (i.e., a larger community involvement implies a smaller use or a larger conservation of the environment):

$$X = \lambda E \text{ and } Y = (\mu/E)$$

Where  $\lambda$  represents the level of environmental technology (i.e., the extent to which consumption affects the environment), and is expressed as the gross domestic product per unit of EF, and  $\mu$  represents the importance attached to the environment within the community (i.e., the extent to which the environment represents a community, where a community could be built on alternative combinations of values, such as dynasty, faith, justice, and solidarity). Finally, all alternative religious environmental ethics considered in this study will refer to the following normalisation:  $\alpha + \nu = 1$  so that  $\alpha$  and  $\nu$  represent the *relative* importance of consumption vs. community.

Note that the use of a CD utility function implies that it is not possible to survive without consumption of goods or without environmental involvement. Moreover, the environment is not defined as a neo-classical collective good (i.e., so that there is rivalry in consumption, and no excludability from consumption), but is instead defined as a form of neo-institutional social capital (i.e., so that community feeling towards the environment can be both complementary and

substitutive of this social feeling). Finally, the use of a CD utility function allows the estimation of  $\alpha$  in terms of the proportion of the total budget allocated to consumption.

Some religious environmental ethics considered in this study will refer to the following welfare function ( $W_C$ , with C representing the current generation here and in subsequent variable names) for representative individuals  $i$  and  $j$  of the current generation:

$$W_C = [W_i^{1-\varepsilon} + W_j^{1-\varepsilon}]^{1/(1-\varepsilon)}$$

This represents a constant elasticity of substitution (CES) utility function where  $W$  represents the individual's welfare and  $\varepsilon$  represents the aversion to intra-generation inequality.

Other religious environmental ethics considered in this study will refer to the following welfare function ( $W$ ) for representative individuals of current and future generations (hereafter, F in variable names):

$$W = [(n_C W_C)^{1-\zeta} + (n_F W_F)^{1-\zeta}]^{1/(1-\zeta)}$$

This represents a CES utility function where  $n_C$  represents the number of people in the current generation,  $\zeta$  depicts the aversion to inter-generation inequality, and  $n_F$  represents the number of people in the future generation. Note that the use of a CES utility function allows the estimation of  $\varepsilon$  and  $\zeta$  in terms of the Atkinson inequality measure. Let us normalise  $n_C$  to 1, and simplify the notation by replacing  $n_F$  with  $n$ , where  $n \neq 1$  if the population changes; and let us introduce the normalized term  $m_C$ , with  $m_C \geq 1$  representing the number of humans plus non-humans with the same dignity in the current generation, and simplify the notation by replacing  $m_C$  with  $m$ .

Note that formalisation of parameter values based on sacred texts requires both precision (to ensure that the results are reliable) and simplification (to eliminate the need to account for doctrinal differences among the different groups within a religion). I will therefore group some religions based on certain philosophical similarities that make them more similar than different from the perspective of the overall analytical framework, and provide examples from the relevant texts so readers can assess the consistency of the simplifications with these texts. Moreover, some religious moral precepts related to nature will be represented as *objectives* (e.g., human dominion over other forms of life in Jewish texts becomes the goal of maximizing inter-generational welfare), some religious moral norms related to nature will be depicted as *constraints* (e.g., the trusteeship of the environment for future generations in Islamic texts becomes a sustainability condition to be met), and some religious moral precepts related to nature will be represented as *parameters* (e.g., the sacred creation in the Eastern Orthodox texts becomes a large  $\mu$ ). However, I will disregard the relationships between divine precepts and natural laws (i.e., to what extent divine laws are translated into the *natural* order), and will disregard the relationships between religions and politics (i.e., to what extent divine moral norms are or should be translated into *social* behaviour or *social* order). Finally, I will measure sustainability based on the EF at the current world population level ( $\theta$ ), and will assume that the future welfare level will be larger than or equal to the current observed level ( $W_C$ ). Let us simplify the notation by replacing  $W_C$  with  $w$ , and use it as a reference for future generations.

In summary, feasibility is represented by pairs of  $\alpha$  and  $\mu$  values that meet the sustainability condition  $\theta$  for alternative values of  $m$ ,  $n$ ,  $\varepsilon$ , and  $\zeta$  in alternative contexts, for a given level of  $w$ , with  $\lambda$  estimated at the current national or mean global level of environmental technology. An increase in  $\alpha$  means a larger relative importance attached to individual consumption than to community involvement, whereas an increase in  $\mu$  means a larger importance attached to the environment within the community.

Some methodological remarks are noteworthy here. The model employed in this study (i.e., the utility functions used to represent preferences) can be justified both theoretically and empirically. In terms of its *theoretical* foundations, one should use a CD utility function whenever the preferences for a set of items are likely to be almost constant. Here, values such as the relative importance of consumption ( $\alpha$ ) vs. community ( $v$ ) are likely to change slowly, if at all. Consequently, an almost constant proportion of the total budget will be allocated to these items (here, to consumption goods). Whenever items for which preferences are expressed can be

considered to be pure substitutes, pure complements, or mixed substitutes and complements (here, the welfare of current and future generations), one should use a CES utility function. In terms of the model's *empirical* foundations, the proportions of the total budget allocated to environmental conservation (below, obtained from national statistics and expressed as a percentage of GDP) can be used to estimate all parameters of the CD utility function (i.e.,  $\alpha$  and  $\nu$ , once the values have been normalized such that  $\alpha + \nu = 1$ ). This can be done by relying on the optimal solution of the usual utility maximization problem subject to an income constraint in the case of a CD utility function. For instance, the optimal expenditure for an item associated with  $\alpha$  in the CD utility function is given by  $[\alpha/(\alpha + \nu)] y$ , where  $y$  is the available income. The degree of aversion to intra- and inter-generational inequality (below, assumed to depict alternative religions) can be used to estimate all parameters of the CES utility function (i.e.,  $\varepsilon$  and  $\zeta$ ) by relying on the one-to-one relationship between the Atkinson inequality measure and a CES utility function, in which welfare increases if inequality decreases. In particular, the Atkinson inequality measure is given by  $1 - [(1/k)\sum(x_i/x^*)^{1-\varepsilon}]^{1/(1-\varepsilon)}$  with  $x_i$  representing the value of item  $i$ ,  $x^*$  representing the mean of the total of  $k$  items, and  $\varepsilon$  representing the inequality aversion parameter.

## 2.1. Hinduism (including Jainism)

In Hinduism, the *Bhagavad-Gita* of the *Mahabharata* (5:18) states “See the presence of God in all, and treat all species with respect”; in the *Vishnu Purana* (3:8:15), “God, Kesava, is pleased with a person who does not harm or destroy other non-speaking creatures or animals”; in the *Atharva Veda*, “Preserve the original fragrance of Earth” (mantras 23 and 25) and “Mother Earth, like a Cosmic Cow, gives us the thousandfold prosperity without hesitation without being outraged by our destructive actions” (mantra 45); in the *Vanaparva* of the *Mahabharata* (25:16), “All creatures act according to the laws of their specific species-behaviour as laid down by the creator. Therefore, none should act in the adharmic way”; in the *Shantiparva* of the *Mahabharata* (109:10), “Dharma exists for the general welfare of all living beings”; also in the *Shantiparva* (139:22), “An action which has been committed by a human being in this life follows him again and again” and (129:21), and “Although a particular person may not be seen suffering the results of his evil actions, yet his children and grandchildren as well as great-grandchildren will have to suffer them”.

In summary, the emphasis is on stewardship, an extended family (i.e., humans, animals, and all living beings) of Mother Earth, respect (based on the cycle of birth and rebirth) up to reverence (based on the incarnation of the supreme being) for other animal species, harmony with all divine creations, ensured (greater than some minimum) wealth to everybody, together with ecological spirituality and individual punishment in future reincarnations or in future generations in the case of actions that contravene the rules of dharma (Dwivedi, 2006; Jain, 2009; Kala and Sharma, 2010; Smith, 2011). Mathematically (where HIN represents the value for Hinduism):

$$W_i = (\lambda_{\text{HIN}} E_i)^\alpha (\mu/E_i)^{1-\alpha} \text{ s. t. } E_i \leq \theta/m \text{ and } W_i \geq w_{\text{HIN}}$$

With  $m \geq 1$ . Thus, solutions can be represented as follows:

$$\alpha_{\text{HIN}} \leq \frac{\ln[w_{\text{HIN}}] - \ln[(\mu m)/\theta]}{\ln[(\theta \lambda_{\text{HIN}})/m] - \ln[(\mu m)/\theta]}, \alpha_{\text{HIN}} \geq 0, \alpha_{\text{HIN}} \leq 1, \mu \geq 0$$

In Jainism, based on the five vows that define Jain practice and that are taken up in the exact same order in the *Yoga Sutras*, one can read “[vow I] non-violence: abstaining from harm to any being that possesses more than one sense, requiring a strict vegetarian diet; [vow III] not-stealing: not only to not take more than is offered, but also not to take more than is needed; [vow V] non-possession: one owns only the bare necessities of life”. In summary, this proposes a lifestyle that goes farther than that of the deepest ecologists (Chapple, 2006). Mathematically:  $E_i \leq s < \theta$ , where  $s$  is the subsistence-level use of the environment. However, this minority religion (i.e., 0.3% of the world's population in 2012) will be disregarded in the remaining analysis because it would be infeasible to extend it to a large population. Similar formalisations can be made for Sikhism (Tanner and Mitchell, 2016).

## 2.2. Buddhism (including Confucianism and Daoism)

In Buddhism, one of the Buddha's Four Noble Truths explains that human suffering is generated by desire and attachment, and that one remedy for such suffering is the practice of compassion and loving-kindness. These practices, included in the Buddha's Eightfold Path, lets us interpret some basic Buddhist principles as a core foundation of environmental concern (*Sutta Pitaka* of the *Tipitaka*): non-harming means the absence of desire to kill or harm, and applies to all beings. In particular, "If one eats the meat of beasts that one has killed or one has caused another to kill, one must spend a hundred thousand kalpas in hell" (i.e., 100 000 lifetimes) according to the *Veludvareyya Sutta*. Moreover, "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" (*Adhammika Sutta*). In particular, one should not put human waste into or spit into water. Finally, "Who has no attachment towards anything, therefore he loves the environment" (*Arahatta Bhikkhu*). In particular, a goal is to seek out calm places for meditation in forests in order to distance oneself from desires.

In summary, the focus is on harmony with nature's laws, and compassion and loving-kindness extended to all beings, together with preservation of nature for its aesthetic value, and both individual and social future punishment in cases of detrimental actions (Kaza, 2006; Shaw, 2017). Mathematically (where BUD represents the value for Buddhism):

$$W_i = (\lambda_{\text{BUD}} E_i)^\alpha (\mu/E_i)^\nu \text{ s.t. } E_i \leq \theta/m, E_i \leq e_{\text{BUD}}, \text{ and } W_i \geq w_{\text{BUD}}$$

Where  $m > 1$ , and where  $e_{\text{BUD}}$  and  $w_{\text{BUD}}$  represent the needs in terms of the use of the environment (e.g., human waste) and in terms of welfare (e.g., human and non-human pain), respectively. Note that escaping from the world would imply a small  $\alpha$ . Thus, similar precepts related to environmental actions characterise Buddhism and Hinduism, although sometimes they have different foundations (e.g., respect for animals in Hinduism is based on animals having been humans in a previous life or humans becoming animals in a subsequent life, whereas respect for animals in Buddhism is based on them suffering like humans in their current life). This suggests that the equilibrium environmental solution presented in Section 2.1 for Hinduism can be used for Buddhism. Here, I have used *equilibrium* to represent the result after accounting for the offsetting effects of all variables simultaneously, where sustainability is maintained in each time (i.e., a steady-state or static equilibrium).

Confucianism has been considered to be a social code of ethics (i.e., social rules to live harmoniously with other human beings) rather than a religion, because it lacks a strong sense of ultimate transcendence in an afterlife. Nonetheless, it shows a great concern for human well-being. If we focus on the 13 classical canons by Confucius, Mencius, and Xunzi, in the *Analects* (a discussion of ethics), we can read "A youth, when at home, should be filial, and, abroad, respectful to his elders". In addition, "In serving his parents, a virtuous man can exert his utmost strength; in serving his prince, he can devote his life"; and in the *Yijing* (a discussion of cosmology), "Yin and yang are the underlying principles of heaven and Earth; they are the web that holds all ten thousand things secure; they are father and mother to all transformations and alterations; they are the source and beginning of all creating and killing". In summary, nature is ultimately composed of one source of energy (Qi); harmony arises from the constant generative action of Yin and Yang; and social order and balance arise between humanity and nature in large ecological systems, together with love for natural beauty (Berthrong, 2006; Clippard, 2016). Mathematically:

$$W_i = (\lambda E_i)^\alpha (\mu/E_i)^\nu \text{ s.t. } \sum r_i E_i \leq \theta$$

Where the weighted sum refers to the relevant (local) community, with  $r_i$  as the relative weight for individual  $i$ . Thus, similar precepts related to environmental actions characterise Buddhism at the individual level and Confucianism at the community level. This suggests that the equilibrium environmental solution presented above for Buddhism can be used for Confucianism if the analysis is performed at the country level.

In Daoism, the *Hua Hu Ching* (a discussion of ethics) provides: “These time-honoured disciplines calm the mind and bring one into harmony with all things; Acceptance is the very essence of the Tao; Foregoing antagonism and separation, one enters in the harmonious oneness of all things; The universe as a harmonious oneness; Simply be aware of the oneness of things.” In *The Way and Its Power* (a discussion of cosmology), “[the Universe is a complex of] ways [that] take as their model their own capacity for self-generation”. In summary, the focus is on harmony with nature, with nature perceived as a flux; on human health, perceived as an equilibrium between the body and its environment through its nine orifices; and on nature, as self-generated objects moving towards an equilibrium (Harry, 2012; Miller, 2006). Note that Daoism is consistent with the theory of evolution and with the ecosystem approach to sustainability. Mathematically:  $E_i \leq s < \theta$  where  $s$  is the subsistence-level use of the environment. However, I will not further consider this minority religion (i.e., 0.1% of world population in 2012) because it is infeasible to extend it to a large population. Similar formalisations are possible for Shinto (Francis, 2014).

### 2.3. Judaism

In the *Old Testament*, *Genesis* (2:15) provides the following: “And the Lord God took man, and put him into the paradise of pleasure, to dress it, and to keep it”; in *Leviticus* (25:3-5), we read: “3. For six years you shall sow your field, and for six years you shall care for your vineyard, and you shall gather its fruits. 4. But in the seventh year, there shall be a Sabbath of the land, a resting of the Lord. You shall not sow your field, and you shall not care for your vineyard. 5. What the soil shall spontaneously produce, you shall not harvest. And you shall not gather the grapes of the first fruits as a crop. For it is a year of rest for the land to care for the land”. In *Deuteronomy* (25:4): “You shall not muzzle an ox as it is treading out your crops in the field”. In *Psalms* (19:1): “The heavens are telling the glory of God/and the firmament proclaims his handiwork”. In *Deuteronomy* (11:17), “And the Lord, becoming angry, might close up heaven, so that the rain would not descend, nor would the Earth produce her seedlings, and then you would quickly perish from the excellent land, which the Lord will give you”. In *Deuteronomy* (20:19), “When you will have besieged a city for a long time, and you will have encircled it with fortifications, so that you may fight against it, you shall not cut down trees from which one is able to eat, neither shall you cause devastation with axes to the surrounding region”. In *Leviticus* (19:19), and similarly in *Leviticus* 10:10-11 and *Deuteronomy* 22:11, “you shall not let your cattle breed with a different kind; you shall not sow your field with two kinds of seeds”. In *Leviticus* (27:27), “The firstborn, which belongs to the Lord, no one is able to sanctify or vow, whether it is an ox, or a sheep, they are for the Lord. In *Leviticus* (27:30): “All the tithes of the land, whether from grain, or from the fruits of trees, are for the Lord and are sanctified to him. In *Deuteronomy* (14:3-6), and similarly in *Leviticus* 11: “3. You shall not eat the things that are unclean. 4. These are the animals which you ought to eat: the ox, and the sheep, and the goat, 5. the stag and the roe deer, the gazelle, the wild goat, the addax, the antelope, the giraffe. 6. Every beast which has a hoof divided into two parts and which also chews the cud, you shall eat.” In *Psalms* (144:15-16), and similarly in *Psalms* 147:9, “O Lord, all eyes hope in you, and you provide their food in due time. You open your hand, and you fill every kind of animal with a blessing”. Note that I returned to the original texts in order to identify the main ethical principles, although I am aware that Jewish practical ethics rely on the Halakhah, which is derived from the Torah through years of debate among senior rabbis.

In summary, humans are seen as “stewards” for future generations, and nature is never an end, but rather it points to the divine creator who governs and sustains it. God is the rightful owner of the land of Israel, and Israelites are God’s tenants; social punishment is provided for sins; and there is an emphasis on preservation of vegetation and conservation of fruit trees for future use, on protection of biodiversity, and on limited consumption of some animals for unspecified reasons; and there is clear evidence of the use of fallow agriculture to restore soil nutrients, improve the soil, and maintain vigorous plants (Tirosh-Samuelson, 2006). Mathematically (where JUD refers to the value in Judaism):

$$\text{Max } W \text{ s. t. } W_i \geq w_{\text{JUD}} \text{ and } E_i \leq \theta \text{ with } \zeta = 1 \text{ and } \varepsilon = 0$$

Thus:

$$W_C = (\lambda_{JUD} \theta)^\alpha (\mu/\theta)^{1-\alpha} = w_{JUD} = n W_F \text{ s.t. } W_i \geq w_{JUD} \text{ and } E_i \leq \theta$$

The solutions can be represented as follows:

$$\alpha_{JUD} \leq \frac{\ln[w_{JUD}/n] - \ln[\mu/\theta]}{\ln[\lambda_{JUD} \theta] - \ln[\mu/\theta]}, \alpha_{JUD} \geq 0, \alpha_{JUD} \leq 1, \mu \geq 0$$

Note that an increase in the population (i.e.,  $n > 1$ ) makes the sustainability conditions stricter (i.e., a lower  $\alpha_{JUD}$  for each  $\mu$ ), although in *Deuteronomy* (14:21) one can read “But whatsoever [animal] is dead of itself, eat not thereof. Give it to the stranger, that is within thy gates, to eat, or sell it to him”. Similarly, on the 7<sup>th</sup> year, debts contracted by fellow Israelites are to be remitted (*Deuteronomy* 15:3). Thus, the concern seems to focus on *Jewish* future generations rather than on *all human* future generations. Moreover, the formalised rules refer to inter-temporal optimal use of natural resources rather than to preservation of nature, although the abovementioned text describes the proper treatment of soil, animals, and vegetation with the goal of maintaining their productivity. Indeed, *Deuteronomy* (22:6-7) states “6 If thou find as thou walkest by the way, a bird's nest in a tree, or on the ground, and the dam sitting upon the young or upon the eggs: thou shalt not take her with her young: 7 But shalt let her go, keeping the young which thou hast caught: that it may be well with thee, and thou mayst live a long time”. Similarly, “during the first three years of growth, the fruits of newly planted trees or vineyards are not to be eaten” (*Leviticus* 19:23). In other words, the whole second creation story in *Genesis* (2:7-15) is likely to have been introduced when the Jewish people transformed from a nomadic population to a sedentary population based on agriculture, in order to face the environmental problems created by agriculture, such as land degradation and desertification, since the food risk cannot be spread over large areas as nomads can do. In contrast, the first creation narrative (*Genesis* 1:1-23) depicts the creation of the material world as an act of imposing order on unordered chaos by serving as a rationale for the distinction between the sacred and the profane. Finally, nature (i.e., God’s creation) is viewed as presently imperfect (i.e., it needs to be redeemed together with the people of Israel), and human management and care, according to divine commands (i.e., God’s revelation), are required to sanctify nature. In other words, nature is not inherently sacred or worthy of veneration, although domestic animals are included in the Sabbath day of rest (*Deuteronomy* 5:13-14), and, consistently, rabbinic Judaism called on Jews to aspire to transcend nature. Thus, a large commitment to nature ( $\mu$ ) as a form of social bonding capital is difficult to achieve.

## 2.4. Christianity (Catholicism, Eastern Orthodox, and Protestantism)

In the *New Testament* (*Matthew* 6:26) one can read: “Behold the birds of the air, for they neither sow, nor do they reap, nor gather into barns: and your heavenly Father feedeth them. Are not you of much more value than they?” There are similar words in *Luke* (12:24). *Matthew* (6:32) says: “For after all these things do the heathens seek. For your Father knoweth that you have need of all these things”. In *Corinthians* (7:31), “And they that use this world, as if they used it not: for the fashion of this world passeth away”. In the *Book of James* (3:7): “For every nature of beasts, and of birds, and of serpents, and of the rest, is tamed, and hath been tamed, by the nature of man”. In summary, humans are seen as “dominators” or “masters” over other forms of life, with no constraints, so that all needs are satisfied (Riley, 2017). Mathematically:

$$\text{Max } W_C \text{ s.t. } W_i \geq w$$

In other words, Christians adopted the first creation story in *Genesis* (1:26-28): “28 And God blessed them, saying: Increase and multiply, and fill the earth, and subdue it, and rule over the fishes of the sea, and the fowls of the air, and all living creatures that move upon the Earth.”

Note that in the *Old Syriac Gospel* by Luke, Jesus is quoted as saying: “Now beware in yourselves that your hearts do not become heavy with the eating of flesh and with the intoxication of wine and with the anxiety of the world, and that day come up upon you suddenly; for as a snare it will come upon all them that sit on the surface of the earth”: in other words, humans and non-

humans have the same dignity or moral value, and this suggests a vegetarian diet; this amounts to the Hindu perspective.

For Catholics, St. Augustine tells us, “Though not required for furnishing of our house, these things [all creatures] are necessary for the perfection of the universe” (*De Ordine*). Similarly, St. Thomas tells us, “As those creatures that are less noble than man exist for the sake of man, whilst each and every creature exists for the perfection of the entire universe” (*Summa Theologica*). In summary, nature is to be admired by Christians, nature is provided by God as a common good for meeting human needs (instrumental values), and imperfect nature needs to be altered by human hands (Hart, 2006; Schaefer, 2009; Warner, 2008). Mathematically:

$$\text{Max } W_C \text{ s. t. } W_i \geq w \text{ with } \varepsilon = 0$$

Note that the first mention of “social injustice” appears in the *Rerum Novarum* of Pope Leo XIII (1891), and this supports  $\varepsilon = 0$ , whereas a more recent emphasis places caring for the community (e.g., in Latin America) before caring for creation. Moreover,  $m = 1$  represents the belief that humans and non-humans are incommensurable (i.e., they must be judged by different standards). Indeed, Pope St. John Paul II (1990) wrote, in *Peace with God the Creator, Peace with all of creation*, that “respect for life and for the dignity of the human person extends also to the rest of creation” or, similarly, that “Christians realise that their responsibility within creation and their duty toward nature and the Creator are an essential part of their faith”. In other words, Catholics seem to move towards Hinduism (i.e.,  $1 < m < \infty$ ), without mentioning sustainability, although the moral values of humans depend on divine grace and faith (e.g., early treatment of American indigenous peoples as non-humans because they had not yet been “saved”). However, the theory of evolution challenges the use of different standards for (i.e., the incommensurability of) humans and non-humans, unless “God is love” (*John* 4:16) and creation is not a one-time event, but rather a continuous giving of life by the Holy Spirit. Finally, seeing Earth’s other creatures and goods as “resources”, as in the Second Vatican Council (1962-1965), supports the absence of any sustainability concept, and suggests that subduing of the Earth should aim at meeting human needs (i.e.,  $W_i \geq w$  for each individual  $i$ ).

Note that in the *Life of St. Francis* by St. Bonaventure, St. Francis is quoted as saying: “Lord, I thank thee for the sufferings thou art sending me. Send me more, if it be thy good pleasure. My pleasure is that you afflict me and spare me not, for the fulfilment of thy holy will is the greatest consolation of my life states”: in other words, humans achieve happiness by meeting God’s will (i.e.,  $\alpha \approx 0$ ), as represented by creation and natural events such as *infirmirate et tribulationes* (i.e., disease and other trials of the flesh). Only humans have liberties. He refers to water, sun, wind, and land as brothers and sisters, so that creation has the same dignity as humans (i.e.,  $m > 1$ ). This approach seems to be similar to Hinduism. However, non-human beings are not mentioned, which is consistent with the incommensurability of humans and animals: indeed, speeches to animals (e.g., birds, wolves) by St. Francis instead represent speeches to social categories of humans (e.g., poor people, pagans). St. Francis states that the use of nature should be only enough to achieve a subsistence life  $s$  (i.e.,  $E \leq s$ ). Mathematically:

$$\theta/E_i \text{ s. t. } E_i \leq s \text{ and } W_i \geq w$$

Thus, sustainability is achieved if  $s \leq \theta$ .

In the Eastern Orthodox religion, St. Gregory of Nyssa states that “The conclusive harmony in the world has not yet been revealed (*On the Creation of Man*). St. John Chrysostom states that “Creation is beautiful and harmonious, and God has made it all just for your sake. He has made it beautiful, grand, varied, and rich” (*On Providence*); “For our sake the Earth was subjected to corruption” (*On Isaiah*). St. Symeon of Thessalonika states that “The Divine Liturgy [celebrating the perception and the very presence of heaven on Earth] constitutes the holy of holies” (*On the Holy Liturgy*). St. Gregory of Nyssa states that “Christ emptied himself, so that nature might receive as much of him as it could hold” (*On the Psalms*). In summary, one should live in faith and love (*vita contemplativa*, the contemplative life) by withdrawing or escaping from the created world; God is omnipotent and independent, while the world is limited, dependent, and incomplete without

God, although the Holy Spirit lets us combine the divine unity, divine transcendence, and God into creation (Chryssavgis, 2006). Mathematically:

$$W_i = (\lambda E_i)^\alpha (\mu/E_i)^{1-\alpha} \text{ and } E_i \leq e \text{ and } W_i \geq w$$

With a large  $\mu$  and a small  $\alpha$ . Thus, sustainability is achieved if  $e \leq \theta$ .

For Protestantism, Martin Luther depicts God as being “with all creatures, flowing, and pouring into them, filling all things” (*Weimar Ausbage*); “When I truly grasp the significance of the incarnation of the Son of God in this world, all creatures will appear a hundred times more beautiful to me than before (*Weimar Ausbage*). Calvin expresses similar feelings in the *Institutes*. Calvin states that “The end for which all things were created was that none of the conveniences and necessities of life might be wanting to men” (*Commentaries on the First Book of Moses called Genesis*); Martin Luther expresses similar sentiments in *Lectures on Genesis*. In summary, the focus is on nature as a manifestation of God, anthropocentrism, an active life (*vita activa*) rather than a contemplative life (*vita contemplativa*), and beauty in nature (Cowdin, 2008; Santmire and Cobb, 2006; Simmons, 2009). Mathematically:

$$\text{Max } W_C \text{ s. t. } W_i \geq w \text{ with } \varepsilon > 0$$

Note that social justice in Protestantism (e.g., the “two Kingdoms” doctrine) supports a positive  $\varepsilon$ , although the ethics of ecological justice are too recent to fix  $\varepsilon = 1$ : this would not ensure sustainability anyway.

In summary, Christianity (Catholicism, Eastern Orthodox, or Protestantism) is not enough to achieve sustainability. Indeed, Christian principles of “equal dignity of humans” (i.e., all siblings as children of the same God) and “love of neighbour” (i.e., love each other as God loved you) do not imply sustainability.

## 2.5. Islam

In the *Qur'an*, one can read: “I am setting on the Earth a vice-regent” (2:31). “It is He who has made you his vice-successors of others on Earth” (6:165), and “Allah loves not mischief” (2:205); thus, “Do not mischief on the Earth after it has been set in order” (7:86). Furthermore, “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” (7:31). “There is no creature that moves in the Earth but it is for Allah to provide it with sustenance” (11:6).

In summary, humans act as trustees for future generations and must show moderation in the utilisation of nature and must use the environment to the smallest possible extent to meet our needs (Foltz, 2006; Muhammadi and Haftador, 2014; Saniotis, 2012). Note that although similar reasoning can be found in the *Sunna*, such as “Live in this world as if you will live in it forever, and live for the next world as if you will die tomorrow” (*Musnad*, 5:440), I have referred to the *Qur'an* as an indisputable source because the deeds and words of the Prophet Muhammad (i.e., the examples of his actions in the *Sunna*) are accepted by Sunnis (around 80% of all Muslims), but not (totally) accepted by Shi'ites, who have compiled their own collection. Mathematically (where ISL represents the parameter value for Islam):

$$\text{Min } E_i \text{ s. t. } W_i \geq w_{\text{ISL}} \text{ and } E_i \geq e_{\text{ISL}} \text{ and } E_i \leq \theta \text{ with } \zeta = 0 \text{ and } \varepsilon = 0$$

Thus, solutions can be represented as follows:

$$\alpha_{\text{ISL}} \leq \frac{\ln[w_{\text{ISL}}] - \ln[\mu/\theta]}{\ln[\theta \lambda_{\text{ISL}}] - \ln[\mu/\theta]}, \alpha_{\text{ISL}} \geq 0, \alpha_{\text{ISL}} \leq 1, \mu \geq 0$$

Note that the role of women in historical Muslim societies justifies  $\varepsilon = 0$ . Moreover, the prohibition against charging interest on a loan in the *Qur'an* (4:161, 30:39, 2:275-278; 3:130) would favour the preservation of renewable resources to a level near the maximum sustainable yields. Finally,  $m = 1$  can be justified as follows. Although the *Qur'an* states that “there is not an animal in the Earth, nor a flying creature on two wings, but they are peoples like unto you” (6:38), suggesting that animals seem to have an existence and a purpose independent of their usefulness to humans, the *Qur'an* also states that cattle and beasts of burden were created to serve humans (26:133 and 36:72). Similarly, in the *Sunna*, Muhammad is believed to have said that: “If you kill, kill well, and if you slaughter, slaughter well. Let each of you sharpen his blade and let him spare

suffering to the animal he slaughters” and “Some trees are as blessed as the Muslim himself, especially the palm”, so Muslims must show compassion towards non-humans and respect for plants. However, human species alone can be rewarded with eternal life, and the aims of humans and non-humans are different. In other words, all of creation submits to the natural laws of Allah, although plants and animals are considered to have a lower dignity than humans.

## 2.6. Summary of religious environmental ethics

Table 1 summarises the objectives and constraints of the religions I have chosen for analysis, and the resulting environmental ethics. Note that Daoism, with its principle of non-action and its depiction of nature as flows through bodies, thereby implying that human health contributes to environmental equilibrium, resembles a dynamic version of Jainism, with its emphasis on asceticism. Moreover, all religions are depicted as concerned only with the current population size (i.e.,  $\theta$  is normalised with respect to the current generation), apart from Judaism, which also considers population dynamics (i.e.,  $n \neq 1$ ). Finally, Islam and Catholicism are depicted as unconcerned about social inequalities (i.e.,  $\varepsilon = 0$ ), although the recent emphasis on labour rights for Catholics and on women’s rights for Muslims must be noted.

**Table 1. Objectives, constraints, and parameters that characterise the main religious environmental ethics.**

| Religion                    | Objectives   | Constraints   | Parameters                             |
|-----------------------------|--|---|--|
| Hinduism                    | $W_i = (\lambda_{\text{HIN}} E_i)^\alpha (\mu/E_i)^{1-\alpha}$ | $E_i \leq \theta/m, W_i \geq w_{\text{HIN}}$  | Large $\mu$                            |
| Jainism                     | $W_i = (\lambda E_i)^\alpha (\mu/E_i)^{1-\alpha}$              | $E_i \leq s$  |  |
| Buddhism                    | $W_i = (\lambda_{\text{BUD}} E_i)^\alpha (\mu/E_i)^{1-\alpha}$ | $E_i \leq \theta/m, E_i \leq e_{\text{BUD}}, W_i \geq w_{\text{BUD}}$   |  |
| Confucianism                | $W_i = (\lambda E_i)^\alpha (\mu/E_i)^{1-\alpha}$              | $\sum r_i E_i \leq \theta, W_i \geq w$  |  |
| Daoism                      | $W_i = (\lambda E_i)^\alpha (\mu/E_i)^{1-\alpha}$              | $E_i \leq s$  |  |
| Judaism                     | $Max W$  | $W_i \geq w_{\text{JUD}}, E_i \leq \theta$  | $n \neq 1, \zeta = 1, \varepsilon = 0$ |
| Christian Catholicism       | $Max W_C$  | $W_i \geq w$  | $\varepsilon = 0$                      |
| Christian Eastern Orthodoxy | $W_i = (\lambda E_i)^\alpha (\mu/E_i)^{1-\alpha}$              | $E_i \leq e, W_i \geq w$  | Large $\mu$                            |
| Christian Protestantism     | $Max W_C$  | $W_i \geq w$  | $\varepsilon > 0$                      |
| Islam                       | $Min E_i$  | $W_i = (\lambda_{\text{ISL}} E_i)^\alpha (\mu/E_i)^{1-\alpha} \geq w_{\text{ISL}}$<br>$E_i \geq e_{\text{ISL}}, e_{\text{ISL}} \leq \theta$ | $\zeta = 0, \varepsilon = 0$           |

Notation:  $\alpha$  = relative importance attached to consumption;  $E_i$  = the use of the environment by individual  $i$ ;  $e$  = needs in terms of the use of the environment for Buddhism, Eastern Orthodoxy, and Islam;  $\varepsilon$  = aversion to intra-generation inequalities,  $\lambda$  = the level of environmental technology (gross domestic product, GDP, per unit of ecological footprint, EF);  $m$  = number of human and non-human beings with the same dignity as human beings divided by the number of human beings (i.e.,  $m \geq 1$ );  $\theta$  = the sustainable use of the environment based on EF;  $\mu$  = the importance attached to the environment within a community;  $n$  = the number of people in the future divided by the number in the current generation (i.e.,  $n > 1$  if population increases);  $s$  = use of the environment to provide the bare necessities of life for Jainism and Daoism;  $W$  = welfare of current ( $W_C$ ) and future ( $W_F$ ) generations;  $w$  = needs in terms of welfare for all religions apart from Jainism and Daoism;  $W_C$  = welfare of current generation;  $W_i$  = welfare of a representative individual  $i$  in the current generation;  $r_i$  = relative weight attached to individual  $i$  in a Confucian community;  $\zeta$  = aversion to inter-generation inequality.

Three main remarks are noteworthy here. First, there is an inconsistency shared by all religions analysed in this paper: they place a high value on each individual for both human and animal lives, whereas for animal lives, sustainability focuses only the species as a whole. Indeed, in Judaism, “O Lord, all eyes hope in you, and you provide their food in due time. You open your hand, and you fill every kind of animal with a blessing” (*Psalms* 144:15-16, and similarly, in *Psalms* 103:2728); in Christianity, “Father feedeth them” (*Matthew* 6:26); in Islam, “There is no creature that moves in the Earth but it is for Allah to provide it with sustenance” (11:6); and in Hinduism, “Mother Earth, like a Cosmic Cow, gives us the thousandfold prosperity without hesitation without being outraged by our destructive actions” (*Atharva Veda*, Mantras 45 and 59).

Second, although the bare environmental necessities (i.e., minimum environmental resources required for survival), as supported by some religions (i.e., Daoism, Jainism), can be used to achieve sustainability, the concepts of the environment’s needs *per se* that are shared by many

religions (i.e., Buddhism, Eastern Orthodoxy, Islam) cannot be assumed to represent a consistent standard of comparison (i.e., a reliable precept), since the concept of needs changes in time and space.

Third, belief in the beauty of nature, in sacred nature, or in the harmony of nature, although supported by different religions in different ways, is insufficient to achieve sustainability, even if this belief is combined with punishment for violating rules (e.g., Eastern Orthodoxy, Buddhism) or is combined with cooperation in an extended community (e.g., Hinduism), since they are not objective behavioural rules. In particular, sacred nature is assumed to be a subjective feeling (i.e., here depicted by  $\mu$ ), similar to a subjective preference for goods (i.e., here, depicted by  $\alpha$ ) rather than to a prescribed action. Indeed, if nature is believed to be created by God or provided as a gift from God, nature has an intrinsic value and humans are then perceived to be members of a natural community. However, unless the use of the environment is at a subsistence level (i.e.,  $E = s$ , and humans live like many animals), with the associated huge opportunity costs for the current generation, belief in sacred nature is not a beneficial rule of action for achieving sustainability unless it is coupled with individual or social (current or future) punishments by deities; this approach is more and more unlikely to be implemented nowadays. Actually, if a river is sacred even if it is polluted (e.g., the Ganges River in Hinduism), one can neglect the social health problems that arise from taking a bath; similarly, if the world is considered to be an impermanent phenomenon, created to serve the deity's purpose (e.g., Islam), one can avoid conservation of nature because that deity's purpose will be finally fulfilled (Grim and Tucker, 2014).

### 3. The empirical literature

Since sustainability is linked to individual and social environmental behaviours, in this section I will refer to the empirical psychological and anthropological literatures to find support for the reliability of the relationship between religions and pro-environmental behaviours. Indeed, psychology aims to identify non-inborn individual motivations based on experiences and objectives (together with incentives) that lead towards pro-environmental behaviour and attitudes of individuals (e.g., an inborn individual behaviour is to increase consumption), whereas anthropology aims at identifying social values based on traditions and perceptions (together with education) that lead towards non-innate pro-environmental behaviour and attitudes of groups (e.g., an innate social behaviour is to increase the population). In other words, psychology assumes a universalist process of cognition (i.e., not strongly affected by cultural differences), and focuses on alternative contents of cognition to identify relationships such as “from religious experiences to pro-environmental behaviour of individuals”, whereas anthropology assumes no distinction between the process and content of cognition by identifying regularities such as “from differences in religious culture to differences in pro-environmental behaviour of groups”.

There is a recent but growing empirical psychology literature that analyses the relationship between specific religious features and pro-environmental behaviours. This literature includes Zaleha (2013), on nature veneration predicting pro-environmental behaviour in the United States; Garfield et al. (2014), on spiritual oneness predicting donations to environmental groups in the United States; Clements et al. (2014), on the pro-environmental attitudes, beliefs, and behaviours of Christians in the United States; Gifford and Nilsson (2014), on a review of the influences on pro-environmental concerns and behaviour of religions, together with some pre-requisites such as knowledge, childhood experiences, activity choices, personality, and perceived behavioural control; Peifer et al. (2016), on the impacts of attendance at religious ceremonies and identity in the United States versus belief in an involved God and biblical literalism on environmental consumption; and Arli and Tjiptono (2017), on the purchase of green products by Muslim and Christian consumers in Indonesia.

However, most research on the relationships between religion and pro-environmental behaviour has been conducted from the perspective of anthropology. In particular, some of the empirical anthropology literature is sceptical about the real role of religions (i.e., beliefs,

perceptions, and practices related to extraordinary, non-material divine beings or forces) in shaping environmental perceptions, attitudes, and behaviours. Indeed, although Judaism, and especially the Reformed and Conservative branches, has turned out to be more environmentally concerned than Christians, the impacts of these attitudes differ according to the alternative measures applied to religion (e.g., synagogue or church attendance, importance of religion in daily life) and to pro-environmental behaviours such as a willingness to support higher environmental spending by the government, a willingness to invest personal funds to protect nature, and self-reported environmental concern (Taylor et al., 2016).

Some anecdotal evidence from the anthropology literature stresses that religions could have a negative impact on pro-environmental behaviour. Indeed, anti-environmental behaviour is often based on fatalistic perspectives (Taylor, 2015). For example, given God's sovereignty, it is arrogant to think that human beings can significantly damage nature; from that perspective, environmental circumstances and changes can then be attributed to divine favour or disfavour due to sin. Consequently, prescribed actions to deal with environmental problems are often ineffective (e.g., prayer, by Christian and Muslim groups; do nothing, since Jesus is coming soon, by Evangelical groups; do nothing, by Hindu groups, since a certain mountain, forest, or river is perceived to be sacred) and thus, not something humans should attempt to change (Sponsel, 2016).

Note that, by emphasising the crucial impacts of overpopulation (e.g., Crist, 2016) and overconsumption (e.g., Twomey and Washington, 2016), some of the speculative anthropology literature is sceptical about the success of religious institutions in promoting the greening of religions by fostering pro-environmental behaviour (Taylor, 2016): First, the number of people who are unaffiliated with any religion is increasing. Second, religions disagree on many points, some of which should be considered to achieve global sustainability (e.g., greed and destructiveness are condemned; restraint and protection are commended; human beings are obliged to live in harmony with the natural world); other points would be useless to achieve global sustainability (e.g., assuming that the natural world has value can be seen as idolatrous; justice, compassion, and reciprocity apply both to human and to non-human beings; there is a continuity of being between human and non-human living beings that can be seen as a rejection of the religious distinction between humans and everything else). Third, religions are institutions that take a long time to change.

## 4. Data and normalisations

In this section, I provide empirical values for the parameters introduced in section 2 that characterise each religion at a national level. In particular, I distinguish all countries where a given religion accounted for more than 50% of the total population in 2010 based on the CIA World FactBook ([www.cia.gov](http://www.cia.gov)). I have excluded Christianity from this analysis, since the analysis in Section 2.4 suggests that it can never achieve sustainability unless it follows the philosophy of St. Francis, in which use of the environment should be at a subsistence level. This approach identified 52 Muslim countries (i.e., Afghanistan, Albania, Algeria, Azerbaijan, Bahrain, Bangladesh, Bosnia-Herzegovina, Brunei, Burkina Faso, Chad, Comoros, Djibouti, Egypt, Eritrea, Gambia, Ghana, Guinea, Guinea Bissau, Indonesia, Iran, Iraq, Jordan, Kazakhstan, Kosovo, Kuwait, Kyrgyzstan, Lebanon, Libya, Macedonia, Malaysia, Maldives, Mali, Mauritania, Morocco, Niger, Nigeria, Oman, Pakistan, Qatar, Saudi Arabia, Senegal, Sierra Leone, Somalia, Syria, Sudan, Tajikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Yemen), 9 Hindu or Buddhist countries (i.e., Bhutan, Cambodia, China, India, Japan, Laos, Myanmar, Sri Lanka, Thailand), and 1 Jewish country (i.e., Israel).

From the World Bank's world development indicators (<http://data.worldbank.org>), I obtained the per capita GDP (purchasing power parity basis, PPP) and population in 2012. I estimated the per capita use of the environment for representative individuals in these countries ( $E_0$ ) using data from the Global Footprint Network (<http://www.footprintnetwork.org>), where the current ecological footprint (i.e., the biologically productive area needed to provide everything an individual uses) is

measured at a national level. The sustainability of a representative individual of the world at the current population level requires  $\theta = 1.7$  ha. I then calculated the weighted averages in population terms of GDP PPP (in USD) and EF (in ha) that characterise a representative individual in Muslim countries (i.e., USD7903 and 1.65 ha), in Hindu or Buddhist countries (i.e., USD9380 and 2.45 ha), and in the one Jewish country (i.e., USD30 879 and 6.20 ha) for which data was available (i.e., in 40, 8 and 1 countries, respectively).

I assumed that consumption can be approximated by income, even though postponed consumption (as a result of saving or investment) affects the welfare of future generations, and assumed that consumption of imported goods increases welfare where they are consumed, although their production might increase use of the environment and so reduce welfare where they are produced and then exported. Based on this assumption, I calculated the current level of  $\lambda$  ( $\lambda_0$ , which represents the current use of the environment for each unit of consumption): 4.98, 4.78, and 3.83 ha for Jewish, Muslim, and Hindu or Buddhist countries, respectively.

The relative frequencies of  $\alpha$  in a population as well as the average current value attached to the bonding environmental capital ( $\mu$ ) are unknown. However, without significant misrepresentation, I assumed that the current welfare of the representative individual ( $w_0$ ) depends on people attaching all value to consumption (i.e.,  $\alpha = 1$ ). Thus, the current welfare level is given by  $w_0 = \lambda_0 E_0$ . This let me calculate the following *approximate* welfare levels of  $w_0$ : 7.903, 9.380, and 30.879 for Muslim, Hindu or Buddhist, and Jewish countries, respectively. Moreover, I assumed that people who attach no value to consumption (i.e.  $\alpha = 0$ ) achieve the current welfare level  $w_0$ : thus,  $w_0 = \mu_0/E_0$  or  $\mu_0 = w_0 E_0$ . This let me calculate the current levels of  $\mu_0$ : 21.51, 56.30, and 1186.99 for Muslim, Hindu or Buddhist, and Jewish countries, respectively. Finally, I multiplied the current public and direct expenditures in environmental conservation as a percentage of GDP by 4 to estimate both public and private expenditures as well as both direct and indirect expenditures. This assumes that these four categories of expenditure have approximately equal values, on average. In future research, it would be worthwhile repeating this calculation with actual values for each category if comparable data becomes available for each country. I did this by estimating the complementary to 1 of the current  $\alpha$  (i.e., I calculated  $1 - \alpha_0$ ). In particular, based on the small amount of available data (unstats.un.org) (i.e., 1.5% of GDP in China, versus 1.2% in Japan, 0.5% in Israel, and 0.4% in Turkey), I estimated the proportions of GDP as 2%, 4%, and 2% for Muslim, Hindu or Buddhist, and Jewish countries, respectively.

Note that these percentages, combined with per capita GDP, evoke an environmental Kuznets curve (i.e., a curve shaped like an inverted U), such that environmental expenditures are small in pre-industrial economies (due to the smaller environmental problems), large in industrial economies (due to the larger environmental problems), and small in post-industrial economies (due to the larger per capita incomes and the higher import of goods and services produced in other countries, thereby shifting environmental impacts to the exporter countries).

This let me estimate the *current* welfare level consistent with all parameter values: 7.903, 9.380, and 30.879 for Muslim, Hindu or Buddhist, and Jewish countries, respectively. Note that the similar welfare ( $u_0$ ) values I obtained from each of the analyses described in this paragraph suggests that the normalizations I applied to  $\mu_0$  had little effect on the results of the analysis (i.e., the impacts of the applied normalisations of  $\mu_0$  are insignificant).

I applied similar reasoning to a globally representative individual. In particular, I used the weighted average values for a globally representative individual (Zagonari, 2018) for GDP PPP (i.e., USD13 348) and EF (i.e., 2.79 ha) to obtain values of  $\lambda_0 = 4.78$  and  $\mu_0 = 37.24$ , and then obtained the value of  $u_0 = 13.348$  based on average current expenditures in conservation of the environment as a proportion of GDP (i.e., 3%).

## 5. Empirical results

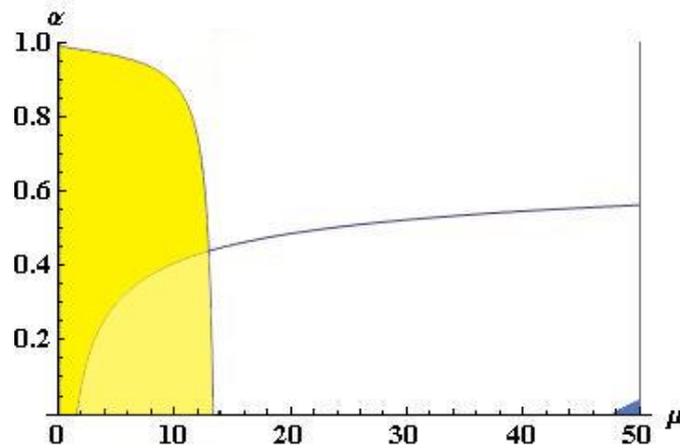
In this section, I apply the parameter values estimated in section 4 to the solutions presented in section 2. In particular, I will check for the sustainability conditions presented in section 2 in

contexts identified by the parameter values estimated in section 4. Appendix I highlights how the solutions related to each religion (e.g., whether  $\alpha$  increases or decreases with increasing  $\mu$ ) depend on the current values of  $\lambda_0$  and  $w_0$ .

## 5.1. Sustainability at current national levels of GDP and EF in countries where the religion is a majority

Figure 1 compares the areas of the solution space where sustainability can be feasibly achieved by Hinduism or Buddhism, by Judaism, and by Islam, if the *respective* religious environmental ethics defined in section 2 are applied in countries where these religions are followed by at least 50% of the population.

**Figure 1. Comparison of the feasibility of religious environmental ethics for achieving sustainability, with the future population set at  $n = 1.1$  and the dignity of non-human beings set at  $m = 10$ . For Judaism (small light blue area at the bottom right side of the figure),  $\mu \geq 47.7$ ; for Islam (yellow and light yellow),  $\mu \leq 13.3$ ; and for Hinduism or Buddhism (light yellow, white area under the increasing curve, and light blue),  $\mu \geq 1.6$ .**



The main insights can be summarised as follows:

- Hinduism and Buddhism (40.1% of the global population) are not constrained by  $\mu$ , although  $\alpha$  must be small: in other words, high levels of consumerism are not allowed when sustainability is achieved.
- Judaism is unlikely to favour sustainability in Israel, since  $\alpha$  must be too small (in contrast with the current lifestyle and with personal wealth seen as a premium from God) and  $\mu$  must be too large (in contrast with evolutionary theory and either pantheism or nature worship). However, Judaism represents only 0.2% of the global population.
- Islam (22.8% of the global population) can be characterised by a large  $\alpha$  and a small  $\mu$ , provided that  $w$  is sufficiently small (i.e., parsimony): in other words, consumerism is allowed, if it is coupled with a small use of the environment.

Note that  $\alpha$  increases with increasing  $\mu$  for Hinduism or Buddhism and for Judaism, whereas it decreases for Islam.

In terms of *feasibility* (i.e., solutions for pairs of  $\alpha$  and  $\mu$ , with  $\mu$  in the range  $[\min \mu, 50]$ ), Hinduism or Buddhism > Islam > Judaism; that is, the feasible areas of the solution space amount to 23.00, 11.91, and 0.04, respectively, where these figures should be multiplied by 2 (= 100 / 50, with 50 = 50 × 1 being the size of the whole feasible area) to obtain the percentage of the total graph area that is feasible. Appendix II confirms this ranking in terms of both the significance and the size of the parameters attached to religious environmental ethics by performing an econometric analysis. Note that defining feasible areas calculated with  $\mu$  in  $[\min \mu, 100]$  would increase the feasibility of Hinduism or Buddhism and of Judaism (i.e., to 52.45 and 12.74, respectively), although such a large involvement in sacred nature is unrealistic for Judaism.

Appendix III provides a sensitivity analysis to illustrate the effects of modifying various parameter values. Figure A1 provides the solution space if  $n$  is set at 0.9 and  $m$  is set at 5. Note that

the feasible area disappears for Judaism, since it produces infeasible values of  $\mu$ . Indeed, a reduced future population combined with inter-generational equity implies that the current generation must rely on belonging to an environmental community to a larger extent (i.e.,  $\mu > 50$ ).

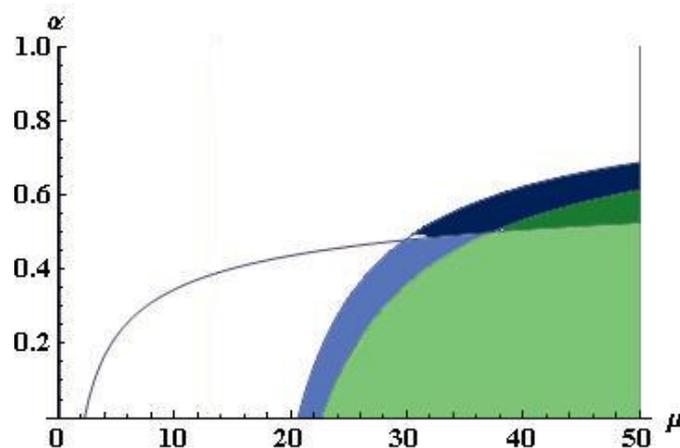
In terms of *consistency* (i.e., whether a feasible sustainability solution could be favoured by the religious characteristics described in Section 2), Hinduism or Buddhism  $>$  Islam  $>$  Judaism. Indeed, stressing the intrinsic value of nature for Hindus or Buddhists (i.e.,  $m > 1$ ) seems to be easier than ensuring moderation in the use of the environment by Muslims (i.e., small  $w$ ), which in turn seems to be easier than reducing the future population for a Jewish country (i.e.,  $n < 1$ ).

Note that the use of greener technology would allow a larger amount of consumerism for Hinduism or Buddhism, but a smaller amount of consumerism for Islam, by decreasing the feasibility for Muslim countries and increasing it for Hinduism or Buddhism (i.e., feasible areas at a 10% larger  $\lambda$  would be 10.19 and 23.38, respectively). Indeed, solutions for Islam are constrained by  $e$  (i.e., the minimum use of the environment to achieve the current welfare level), whereas solutions for Hinduism or Buddhism are constrained by  $\theta$  (i.e., any welfare level consistent with a sustainable use of the environment). The reasoning for Hinduism or Buddhism also applies to Judaism, since welfare is not constrained, whereas welfare is maximised in Judaism. Moreover, allowing a larger  $\alpha$  in Muslim countries could favour economic growth by supporting domestic demand. Finally, the calculated feasibility rankings of the religions differ from the observed order of countries where the religion is a majority in terms of their current use of the environment (i.e., religions can conceivably play a role in solving environmental issues in different countries).

## 5.2. Sustainability at average world levels of GDP and EF

Figure 2 compares the areas of the solution space where sustainability can be feasibly achieved by Hinduism or Buddhism, by Judaism, and by Islam if the respective religious environmental ethics are applied to an average globally representative country (e.g., if a more equal income distribution is achieved in the future).

**Figure 2. Comparison of the effectiveness of achieving sustainability based on religious environmental ethics, with the future population set at  $n = 1.1$  and with the dignity of non-human beings set at  $m = 10$ . For Judaism (blue and light blue, green, and light green areas),  $\mu \geq 20.6$ ; for Islam (green and light green areas),  $\mu \geq 22.7$ ; and for Hinduism or Buddhism (white area under the first increasing curve from the left, light blue and light green),  $\mu \geq 2.3$ .**



Since the alternative environmental ethics characterising the analysed religions are applied to the same unsustainable but possible world scenario, the feasibility ranking can be interpreted as an effectiveness ranking (i.e., the potential of each religion to solve the same environmental problem).

In terms of *effectiveness* (i.e., efficiency in achieving sustainability in an average world scenario), Hinduism or Buddhism  $>$  Judaism  $>$  Islam (i.e., with feasible areas of 20.53, 15.12, and 11.95, respectively). Note that Judaism, with the largest  $\alpha$ , turns out to be the religion most suited to the hyper-inflated Western lifestyle, which is based on high consumption of energy and goods

(Tucker, 2015), although  $\alpha$  turns out to be significantly smaller than 1 (i.e.,  $\alpha \leq 0.69$ ), and it must be coupled with a sufficiently large  $\mu$ .

Figure A2 in Appendix III provides the solution spaces if  $n$  is set at 0.9 and  $m$  is set at 5. Note that Judaism is less effective than Islam if the population decreases. Indeed, the future generation could rely on a larger per capita use of the environment and will achieve a smaller total welfare, which requires a smaller consumerism by the current generation, due to inter-generational equity.

The main insights can be summarised as follows:

- Hinduism and Buddhism are slightly constrained by  $\mu$  (i.e.,  $\mu \geq 4$ ) if  $m$  is sufficiently large (i.e.,  $m \geq 5$ ), although they do not allow the same degree of consumerism as Judaism and Islam (i.e., they have a smaller  $\alpha$ ),
- Judaism allows the largest consumerism (i.e., the largest  $\alpha$ ) if the involvement in a local or global environmental community is large enough (i.e.,  $\mu \geq 26$ ).
- Islam allows a smaller degree of consumerism than Judaism (i.e., a smaller  $\alpha$  for each  $\mu$ ), and it requires a larger  $\mu$  than Hinduism or Buddhism and Judaism.

Note that for Islam, applying the solutions to a representative country implies  $\alpha$  increasing with increasing  $\mu$ .

### **5.3. Sustainability at current national levels of GDP and EF for countries in which each religion is a minority**

Figures 3 to 5 compare the areas of the solution space in which sustainability can be feasibly achieved by Hinduism or Buddhism, by Judaism, and by Islam if these religious environmental ethics are applied to countries where they represent minority religions (i.e., where these religions are followed by less than 50% of the population). Since the parameter values based on the alternative environmental ethics that characterise the analysed religions were applied to the same currently unsustainable scenarios in countries where the religion is a minority, the effectiveness ranking can be interpreted as a *replicability* ranking (i.e., as the potential of each religion to solve the same environmental problem in countries where other religions prevail).

To broaden the scope of the insights into current and future sustainability, let us assume that Muslim countries represent pre-industrial economies, that Hindu or Buddhist countries depict industrial economies, and that Israel represents a post-industrial economy. Patently, this is a simplification, and some exceptions can be easily proposed. For example, Turkey is a Muslim country, but it is an industrial economy, whereas Japan is a Buddhist country, but it is a post-industrial economy. However, the calculation of weighted averages in population terms of GDP and EF for countries where the agriculture sector accounts for more than 16% of GDP (pre-industrial societies), where the industry sector accounts for more than 32% of GP (industrial societies), and where the service sector accounts for more than 64% of GDP (post-industrial societies) based on global data ([www.worldbank.org](http://www.worldbank.org)) can be used to select pre-industrial, industrial, and post-industrial economies, respectively. So doing produces a ranking of GDP similar to the ranking obtained by selecting majority Muslim, Hindu or Buddhist, and Jewish countries, respectively. Indeed, population-weighted GDP for post-industrial economies = 32 488 US\$ > GDP for industrial economies = 10 324 US\$ > GDP for pre-industrial economies = 3358 US\$. These values are similar to the population-weighted GDP for Israel = 30 879 US\$ > GDP for Hindu or Buddhist countries = 9380 US\$ > GDP for Muslim countries = 7903 US\$, and the values are strongly and significantly correlated (Pearson's  $r = 0.99$ ,  $p < 0.05$ ). Similarly, the ranking of EF for pre-industrial, industrial, and post-industrial economies is similar to the ranking of EF for majority Muslim, Hindu or Buddhist, and Jewish countries, respectively. Indeed, population-weighted EF for post-industrial economies = 5.21 > EF for industrial economies = 2.52 > EF for pre-industrial economies = 1.16. These values are similar to the population-weighted EF for Israel = 6.20 > EF for Hindu or Buddhist countries = 2.45 > EF for Muslim countries = 1.65, and the values are strongly and significantly correlated (Pearson's  $r = 0.99$ ,  $p < 0.05$ ).

Figure 3. Comparison of the replicability of religious environmental ethics for achieving sustainability in *pre-industrial* economies, with  $n = 1.1$  and  $m = 10$ . For Judaism (green and light green areas),  $\mu \leq 12.1$ ; for Islam (yellow and light yellow, green and light green areas),  $\mu \leq 13.3$ ; and for Hinduism or Buddhism (light green, light yellow, white area under the increasing curve),  $\mu \geq 1.3$ .

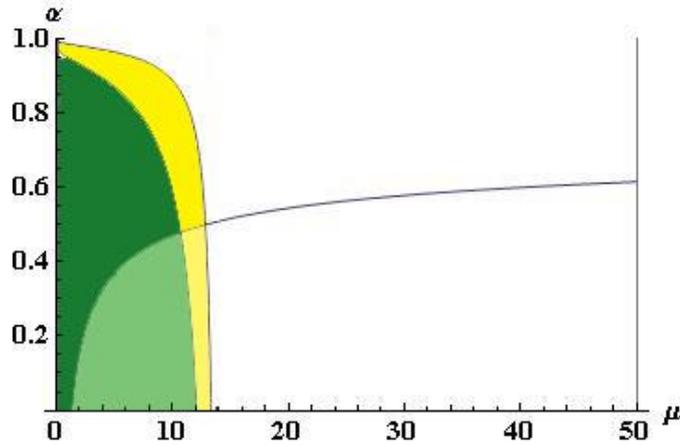


Figure 4. Comparison of the replicability of religious environmental ethics for achieving sustainability in *industrial* economies, with  $n = 1.1$  and  $m = 10$ . For Judaism (blue and light blue, green and light green areas),  $\mu \geq 14.5$ ; for Islam (green and light green areas),  $\mu \geq 15.9$ ; and for Hinduism or Buddhism (white area under the increasing curve, light blue and light green),  $\mu \geq 1.6$ .

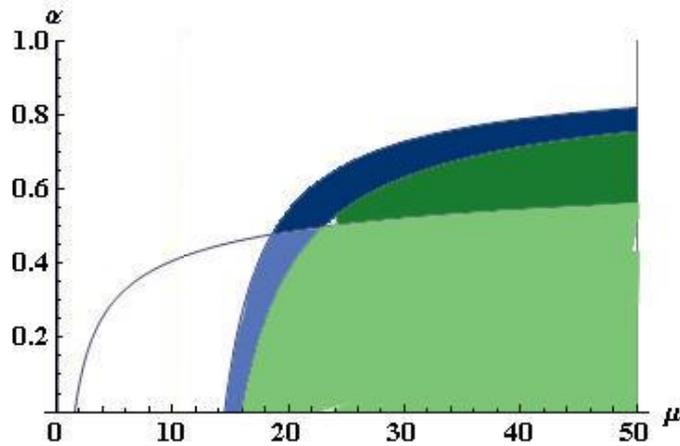
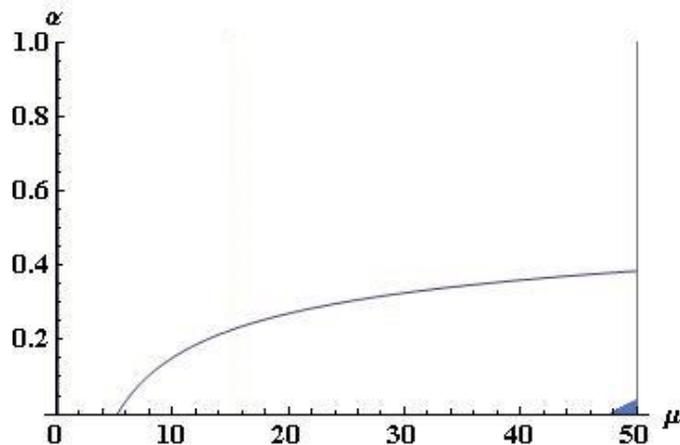


Figure 5. Comparison of the replicability of religious environmental ethics for achieving sustainability in *post-industrial* economies, with  $n = 1.1$  and  $m = 10$ . For Judaism (small light blue area at the bottom right side of figure),  $\mu \geq 47.7$ ; for Islam,  $\mu \geq 52.5$  (i.e., there are no feasible  $\mu$ ); and for Hinduism or Buddhism (white area under the increasing curve, and light blue),  $\mu \geq 5.2$ .



Note that the thresholds I chose for the type of economy (i.e., 16, 32, and 64% of GDP) produced some countries in which the development level could not be clearly distinguished because none of the thresholds were exceeded (i.e., in 11 out of 135 cases) or in which two development levels were possible because two thresholds were exceeded (i.e., in 4 out of 133 cases). In these 15 cases, the country was allocated to a development level category based on the threshold closest to its actual percentage of the economy from below and the threshold farthest from this percentage from above. For example, the Ukraine was 7, 4, and 1 percentage points below the thresholds for pre-industrial, industrial, and post-industrial countries; as a result, I allocated the Ukraine to the post-industrial development level. In contrast, Uzbekistan had values 3 and 1 percentage points above and 16 points below the respective thresholds, so I allocated it to the pre-industrial development level.

These identifications let me discuss the potential use of the principles that characterise a given religion in countries that are currently at the same and different levels of industrial development in countries where the religions are currently a majority (e.g., to suggest that the principles of Judaism apply to post-industrial, industrial, or pre-industrial countries, instead of applying Judaism to Israel, Hindu or Buddhist, or Muslim countries).

Obviously, the results based on data that characterises different religions will be quantitatively different from results based on data that characterises different development classes. However, the obtained insights are qualitatively similar. These results are presented in Figures A6 to A8 of Appendix III.

The main insights can be summarised as follows, without accounting for the impacts on sustainability of the current and future global level of imports and exports:

- Hinduism and Buddhism are feasible in pre-industrial, industrial, and post-industrial countries, although they are less effective in post-industrial countries.
- Judaism can be applied to pre-industrial countries, although it is less effective than Islam, whereas it is the most effective set of principles for industrial countries.
- Islam is not feasible in post-industrial countries, and it is less effective than Judaism in industrial countries.

Note that  $\alpha$  decreases with increasing  $\mu$  for Judaism if this set of religious ethics is applied to pre-industrial economies.

In terms of *replicability* (i.e., effectiveness in achieving sustainability in countries where the religion is a minority): Hinduism or Buddhism > Judaism > Islam. Indeed, Hinduism or Buddhism > Islam > Judaism in pre-industrial economies (i.e., with feasible areas of 25.81, 11.91, 9.23, respectively); Judaism  $\approx$  Hinduism or Buddhism > Islam in industrial economies (i.e., with feasible areas of 24.24, 23.00, 20.49, respectively); and Hinduism or Buddhism > Judaism, and Islam is infeasible, in post-industrial economies (i.e., with feasible areas of 12.83 and 0.04, respectively).

Note that if pre-industrial countries are sustainable by following Islamic principles, provided that  $w_{ISL}$  and  $e_{ISL}$  are small, they can also be sustainable according to the same principles if they become industrial economies, provided that  $\mu$  increases and  $\alpha$  decreases. In other words, Islamic principles are ineffective for industrial economies, but they are still feasible. Similarly, if industrial countries are sustainable by following Hindu or Buddhist principles, provided that  $\alpha$  is small, they can also be sustainable according to the same principles if they become post-industrial economies, provided that  $\mu$  increases. In other words, Hindu or Buddhist principles are ineffective, but they are still feasible.

Figures A3 to A5 in Appendix III provide solution spaces if  $n$  is set at 0.9 and  $m$  is set at 5. Note that if the population decreases, Judaism becomes the most effective set of religious ethics for pre-industrial economies.

## 6. Discussion

The overall insights obtained from the analytical model developed in Section 2 and applied to the data presented in Section 4 can be summarised as follows: In terms of feasibility, the principles

of equilibrium that underlie Hinduism and Buddhism are the most reliable ways to achieve sustainability, although this implies a smaller degree of consumerism. The principles of parsimony and trusteeship that underlie Islam are effective at the lowest stages of development (i.e., pre-industrial economies), which are currently the conditions prevailing in many Muslim countries, but they are the least effective way to achieve sustainability at higher stages of development. Indeed, minimising the use of the environment subject to a maximum welfare level  $w$  is less constrained if  $w$  is small. The principles of stewardship that underlie Judaism are inadequate for the current unsustainable levels of consumption in Israel (i.e., a post-industrial economy), although they are the most effective way to achieve sustainability at an average stage of development. That is, maximising welfare subject to sustainability constraints is more effective than minimizing use of the environment subject to welfare constraints, as suggested by the Islamic precepts, and is more effective than adapting welfare to sustainability conditions, as suggested by the Hindu and Buddhist principles.

In terms of consistency with its religious principles, Israel could have problems in promoting the sanctity of nature (i.e., a larger  $\mu$  is inconsistent with the *Old Testament*), although they could rely on a reduced population (i.e., a smaller  $n$ ). Moreover, Hindu and Buddhist countries have no problem emphasising the dignity of non-human beings (i.e., a large  $m$ ), although they could have problems in maintaining a small relative value attached to consumption (i.e., a small  $\alpha$ ). Finally, Muslim countries could have problems promoting satisfaction with a low consumption of the environment (i.e., a small  $w$  is consistent with the *Qur'an*), although they could rely on technological improvements to accomplish this (i.e., a larger  $\lambda$ ).

Note that adopting greener technology (i.e., a larger  $\lambda$ ) might be detrimental for pre-industrial economies that adopt Islam (i.e.,  $\alpha$  decreasing with increasing  $\mu$ ), since it implies a smaller domestic demand (i.e., a larger  $\lambda$  implies a smaller  $\alpha$  at equilibrium), whereas it would be beneficial for industrial and post-industrial economies that adopt Judaism (i.e.,  $\alpha$  increases with increasing  $\mu$ ), as it would allow higher domestic demand (i.e., a larger  $\lambda$  implies a larger equilibrium  $\alpha$ ). Indeed, if Islam is adopted, an increase in consumption  $X$  due to an improvement in technology  $\lambda$ , because of fixed needs in terms of welfare  $w$ , must be compensated for by a reduction in the relative importance attached to consumption  $\alpha$ . In contrast, if Judaism is adopted, an increase in consumption  $X$  due to an improvement in technology  $\lambda$  must *not* be compensated for by a reduction in the relative importance attached to consumption  $\alpha$ , since what is fixed is the use of the environment at its sustainability level  $\theta$ . The reasoning for Judaism also applies to Hinduism and Buddhism, since welfare is not constrained, whereas welfare is maximised in Judaism.

The main weaknesses of the approach adopted in the present study are that:

- It does not account for differences in religions at a national level (e.g., Chinese versus Japanese Confucianism) or at the level of a given overall faith (e.g., Evangelists versus Baptists within Christianity) (Pedersen, 2015). However, because my focus was on the main shared precepts of a given religion, this should not be a major problem.
- I parametrised the model for countries where a majority of the people believe in a given religion, although different environmental practices are observed in countries characterised by the same religion, and many people with a given religion live in countries where they are not the religious majority (Saniotis, 2012). However, because my analysis stresses a few of the main precepts of each religion, it achieves overall insights that can be interpreted as dependent on individual income levels (e.g., Islam provides the easiest rules to achieve sustainability at a low income, although a higher income requires a larger  $\mu$  than in Hinduism or Buddhism and a smaller  $\alpha$  than in Judaism).
- The analysis neglects indigenous religions in Africa (Olupona, 2006) and other traditional societies such as Native Americans (Grim, 2006), mainly because these religions are based on oral traditions and provide no canonical texts that can be used as the source of inferred parameter values. However, although these religions differ in many features, they suggest similar pathways for personal maturity, communal identity, spiritual ecology, and

cosmological contemplation; in other words, they are all consistent with sustainability based on precepts that are orally transmitted from generation to generation.

- Recent changes of religions to account for the growing recognition of a global environmental crisis are disregarded (Tucker, 2006). However, because my focus was on the main shared precepts of a given religion, this should not be a major problem.

Note that there are similarities among the most popular sustainability paradigms and religious environmental ethics. Weak sustainability (i.e.,  $Max W_i s.t. W_F \geq W_C$ ) is close to Judaism; a-growth (i.e.,  $Min E_i s.t. W_F \geq W_C$ ) is close to Islam; de-growth (i.e.,  $Min X_i s.t. W_i \geq w$ ) evokes the approach in Christianity, although Max  $W$  is replaced by Min  $X$ ; and strong sustainability (i.e.,  $Max W s.t. E_i = E_j$ ) evokes the approach in Hinduism or Buddhism, although  $W \geq w$  is replaced by Max  $W$ .

The main strengths of the adopted approach are that:

- The analytical model is simple but comprehensive (i.e., it includes all relevant features) and it is realistic (i.e., it can be validated with observed data), so its insights depend on the application of formulas inferred from core religious texts and the use of parameter values based on real data (e.g., Islamic principles show different feasibility, consistency, and effectiveness with parameter values that characterise Muslim countries today, as pre-industrial economies, and could be modified to characterise Muslim countries tomorrow, as industrial economies).
- The framework is based on original precepts from each religion, without relying on past alternative interpretations and without requiring future interactions between religions. In other words, for the sake of realism, we should avoid sustainability achievements that rely on impossible (in the short-run) and implausible (in the long-run) compromises between religions to cope with an urgent issue. However, my analysis suggests potential directions of fruitful dialog between religions (i.e., positive interactions) by identifying parameter areas that are shared by some religions (e.g., both Judaism and Islam should increase involvement in a community, with  $\mu \geq 30$ , whereas both Hinduism or Buddhism and Judaism should decrease consumerism, with  $\alpha \leq 0.5$ ). It also suggests potential directions of unfruitful dialog between religions (i.e., negative interactions) by identifying principles that should not be adopted by other religions (e.g., Hinduism should not increase  $\alpha$ , and Islam should not increase  $\mu$ ). For example, Judaism could increase  $\mu$  and decrease  $\alpha$  by learning from Hinduism or Buddhism; by contrast, Hinduism or Buddhism and Islam should not increase consumerism by learning from Judaism.
- The framework refers to community involvement, without relying on the extension of religious ethical principles to other communities. In other words, to avoid unproductive debate that would delay efforts to achieve sustainability, some variations among the sects or subdivisions of a given religion (e.g., the dozens of Christian denominations) should prevent the imposition of different interpretations of the same sacred text on environmental ethics. However, the analysis suggests which beliefs should be changed to achieve sustainability for some religions (e.g., Christianity should adopt the Eastern Orthodox principles by replacing  $e$  with  $\theta$  as the constraint).
- The analysis identified potentials and difficulties in achieving sustainability for the main religions, without requiring an extension of precepts and proscriptions of one religion to other religions. In other words, to avoid the potential for violence, imposition of principles from one religion on other religions should be prevented. However, in order to account for modern multicultural societies, I discussed the potential applicability of principles characterising the interaction between a religion and the level of industrial development in its host society (e.g., Islam is unfeasible in post-industrial economies, whereas Judaism is ineffective in pre-industrial economies).

Note that future technological developments (e.g., genetic engineering) might challenge some religious environmental principles (e.g., stewardship of past or current biodiversity) and might

affect species conservation practices (e.g., if technology lets us record the genetic map of a species and regenerate that species whenever we desire, conservation of that species becomes less important). Moreover, believing in the intrinsic value of nature does not mean that it has a fixed value. For example, a static perspective based on resistance to change could produce different values than a dynamic perspective based on resilience against change, fitness, or diversity. However, the concept of the environment as a form of bonding social capital is broad enough to include both a static perspective (e.g., Judaism) and a dynamic perspective (e.g., Daoism). Finally, the acceptance of scientific findings (e.g., evolution) might affect the foundations of some religious principles such as the sanctity of nature.

## 7. Conclusions

Many examples of bad local environmental management can be observed in the past. However, the world now faces serious global environmental issues. The main *question* underlying this paper is whether each religion can respond to these issues in a way that will favour global sustainability based on its unique combination of ethical precepts applied at a community level. In particular, there seems to be no perception that all religions should adopt a common code of religious environmental ethics to be applied universally to achieve global sustainability, since my analysis identified few precepts unique to each religion that could motivate people to take action. Moreover, although religion might not be the optimal solution for global environmental issues, sacred texts, regardless of their divine origin, represent the major source of values by which individuals and societies rank possible outcomes and make decisions. On this basis, religions could help educate children to be better environmentalists and less consumerist, since religions can rely on additional tools such as the concept of *sin* or the prospect of an *afterlife* to mould behaviours, and can also implement social sanctions within a religious community. Finally, there seems to be no need for religious ethics to enter the realm of politics to achieve global sustainability, since around 85% of the world's people claim to believe in some religion and its principles ([www.adherents.com](http://www.adherents.com)). In other words, although religions have only recently begun to explicitly deal with environmental issues (e.g., the first Christian symposium on the environment occurred in 2002), religions can continue to promote transformation of beliefs and attitudes into values and practices that are more likely to lead us to sustainability. Such an approach can support decision-making under the uncertainty characterising environmental issues where secular principles such as justice or responsibility are inadequate or unfeasible.

The main *answer* obtained by this paper is that the principles of parsimony and trusteeship in Islam and the principle of equilibrium in Hinduism and Buddhism can promote sustainability for the majority of the global population (i.e., for the 62.9% of the population who belong to these religions). However, to achieve this goal, Muslim countries must maintain a small use of the environment, and Hindu or Buddhist countries must continue to attach a small relative value to consumption. Note that an increase in the perceived dignity of non-humans in Hinduism or Buddhism and the adoption of greener technology by Muslim countries can reinforce the stability of these sustainability solutions.

Unfortunately, the analysis identified three main negative consequences. First, the principle of stewardship in Judaism is ineffective at the currently unsustainable levels of use of the environment in Israel, since achieving sustainability would require a much smaller importance attached to consumption (i.e., the opposite of the modern Western life-style), a large sanctity of nature (i.e., as opposed to belief in evolution and in opposition to Jewish precepts), and a significant population decrease, which is a very sensitive point to a people who have been repeatedly threatened with extinction. However, Judaism accounts for only 0.2% of the global population, so its overall impact on global sustainability is small.

Second, my analysis identified no feasible solutions for Christians, which is consistent with the seminal paper by White (1967). In other words, Christians (31.3% of the global population) must rely on secular feelings and principles such as justice and responsibility towards nature and

future generations, since Christian precepts (e.g., love of neighbours) seem to provide weak support for sustainability. However, this could be interpreted as non-significant bad news, since faith in the (mostly) high-income Christian countries is decreasing, whereas secular principles (e.g., aversion to intra- and intergenerational inequity) seem to be more and more important.

Third, Islam (22.8% of the global population) is effective at achieving sustainability under current (pre-industrial) conditions in Muslim countries if it is coupled with a small use of the environment, although it will not be effective at the higher future income levels targeted by the development plans of these countries. However, technological improvements could be implemented, coupled with a stable and low level of consumerism.

Note that my model does not directly depict people who claim to be believers but whose behaviour may not agree with the prescriptions and proscriptions of their nominal religion (e.g., Christian businessman). However, since sustainability is always an opportunity cost (and often a monetary cost), the effect of this contradiction is likely to be smaller if behaviour must change in the directions embodied in the principles that have arisen from the prevailing social values (e.g., a growing recognition of the need for inter-generational equity). Moreover, it is improbable that a global religion will arise that represents a compromise between religions and that copes with urgent environmental issues, and it is groundless that such a religion would be able to combine the alternative environmental ethics or different parameter values. However, if we rely on the effects of the principles that characterise minority religions, which sometimes account for a significant proportion of the total population, the cumulative effects may represent a possible route to achieve sustainability in modern multi-cultural societies. Finally, the model does not directly account for people who declare themselves to be atheists or agnostics, although their behaviour might agree with some principles of some religion. However, since religious principles are embodied in laws (e.g., Catholic thinking shapes the approaches of most political parties in Italy) and since individual behaviour is directly or indirectly affected by the attitudes of others within the same society, religious principles are likely to be consciously or unconsciously implemented by these people.

Three main positive consequences were identified. First, it appears that requiring belief in the sanctity of nature is not crucial for achieving sustainability. Second, principles leading to sustainability exist in all of the religions I analysed (e.g., stewardship in Judaism, trusteeship and parsimony in Islam, equilibrium in Hinduism or Buddhism), and these are independent of scientific findings (e.g., evolutionary theory). Indeed, religious ethics must favour sustainability by affecting the behaviours of members of each religion, without requiring changes in response to scientific breakthroughs (e.g., Buddhism supports recycling, but does not specify the means). In other words, religious ethics cannot be taken as the source of an efficient environmental policy, but can support the development of such a policy. This is perhaps fortunate, since religions have proven to respond slowly, often over periods of centuries, to key scientific breakthroughs. However, this is a case in which science and religion can work together to achieve a better result than either can achieve alone: science has no inherent code of ethics, which is something that religion can provide; conversely, religion has no updated means to implement nature preservation, which is something that science can suggest. In other words, religious ethics can define goals (i.e., minimise use of the environment in Islam, maximise human welfare in Judaism, achieve an ecological equilibrium in Buddhism or Hinduism), and science can suggest how those goals can be achieved. Third, altering the dynamics of populations is not crucial for achieving sustainability.

Note that insights obtained in this paper are based on current data at a national level applied to produce static analytical results. Future research should try to perform a similar empirical analysis at a smaller scale (e.g., at the community level), to account for differences among countries or within religions in specific social characteristics and exegetical interpretations, and should try to theoretically analyse the dynamics of different religions, to predict both independent dynamics (e.g., Islam and Christianity are evangelical religions, whereas Judaism and Hinduism and Buddhism are not) and inter-dependent dynamics (e.g., Islam and Christianity are less likely to coexist, whereas Hinduism or Buddhism and Christianity are more likely to interact).

## Appendix I: analytical results

In this section, I will analyse the three main religious environmental ethics that offer the possibility of sustainability in order to characterise the constraints introduced in Section 2 in terms of observable parameters. In particular, I will neglect Christianity, since the analysis in Section 2.4 of the main text suggests that it can never achieve sustainability unless it follows the philosophy of St. Francis, in which use of the environment should be at a subsistence level. Moreover, I will combine Hinduism and Buddhism, since their precepts largely have the same consequences, although the precepts are differently justified. Finally, I will neglect Jainism and Daoism, since they both achieve sustainability by referring to use of the environment at a subsistence level.

Therefore, for Hinduism or Buddhism, either  $\alpha$  is decreasing in response to increasing  $\mu$ :  
 $\alpha_{\text{HIN}} > 0 \leftrightarrow \mu < w_{\text{HIN}}(\theta/m)$  and  $\mu < (\theta/m)^2 \lambda_{\text{HIN}}$ ;  $\alpha_{\text{HIN}} < 1 \leftrightarrow w_{\text{HIN}} < (\theta/m) \lambda_{\text{HIN}}$   
 $\partial \alpha_{\text{HIN}} / \partial \mu < 0 \leftrightarrow w_{\text{HIN}} < \lambda_{\text{HIN}} (\theta/m)$  (1)

Or  $\alpha$  is increasing in response to increasing  $\mu$ :

$\alpha_{\text{HIN}} > 0 \leftrightarrow \mu > w_{\text{HIN}}(\theta/m)$  and  $\mu > (\theta/m)^2 \lambda_{\text{HIN}}$ ;  $\alpha_{\text{HIN}} < 1 \leftrightarrow w_{\text{HIN}} > (\theta/m) \lambda_{\text{HIN}}$   
 $\partial \alpha_{\text{HIN}} / \partial \mu > 0 \leftrightarrow w_{\text{HIN}} > \lambda_{\text{HIN}} (\theta/m)$  (2)

Where:

$\partial \alpha_{\text{HIN}} / \partial m > 0 \leftrightarrow \mu < w_{\text{HIN}}^2 / \lambda_{\text{HIN}}$ ;  $\partial \alpha_{\text{HIN}} / \partial \lambda_{\text{HIN}} > 0 \leftrightarrow \mu > w_{\text{HIN}}(\theta/m)$

Note that the second set of conditions (2) applies if  $m$  is large (i.e., if humanity's natural family is extended to non-human beings), if  $\lambda_{\text{HIN}}$  is small (i.e., the use of the environment is technologically inefficient), or if  $w_{\text{HIN}}$  is large (e.g., in an industrial economy).

For Judaism, either  $\alpha$  is decreasing with increasing  $\mu$ :

$\alpha_{\text{JUD}} > 0 \leftrightarrow \mu < (w_{\text{JUD}}/n) \theta$  and  $\mu < \theta^2 \lambda_{\text{JUD}}$ ;  $\alpha_{\text{JUD}} < 1 \leftrightarrow w_{\text{JUD}}/n < \theta \lambda_{\text{JUD}}$   
 $\partial \alpha_{\text{JUD}} / \partial \mu < 0 \leftrightarrow w_{\text{JUD}}/n < \lambda_{\text{JUD}} \theta$  (3)

Or  $\alpha$  is increasing with increasing  $\mu$ :

$\alpha_{\text{JUD}} > 0 \leftrightarrow \mu > (w_{\text{JUD}}/n) \theta$  and  $\mu > \theta^2 \lambda_{\text{JUD}}$ ;  $\alpha_{\text{JUD}} < 1 \leftrightarrow w_{\text{JUD}}/n > \theta \lambda_{\text{JUD}}$   
 $\partial \alpha_{\text{JUD}} / \partial \mu > 0 \leftrightarrow w_{\text{JUD}}/n > \lambda_{\text{JUD}} \theta$  (4)

Where:

$\partial \alpha_{\text{JUD}} / \partial n < 0 \leftrightarrow \mu < \theta^2 \lambda_{\text{JUD}}$ ;  $\partial \alpha_{\text{JUD}} / \partial \lambda_{\text{JUD}} > 0 \leftrightarrow \mu > (w_{\text{JUD}}/n) \theta$

Note that the second set of conditions (4) applies if  $\lambda_{\text{JUD}}$  is small (i.e., the use of the environment is technologically inefficient), if  $n$  is small (i.e., the future population is smaller than the current population), or if  $w_{\text{JUD}}$  is large (e.g., in a post-industrial economy).

For Islam, either  $\alpha$  is decreasing with increasing  $\mu$ :

$\alpha_{\text{ISL}} > 0 \leftrightarrow \mu < w_{\text{ISL}} \theta$  and  $\mu < \theta^2 \lambda_{\text{ISL}}$ ;  $\alpha_{\text{ISL}} < 1 \leftrightarrow w_{\text{ISL}} < \theta \lambda_{\text{ISL}}$   
 $\partial \alpha_{\text{ISL}} / \partial \mu < 0 \leftrightarrow w_{\text{ISL}} < \lambda_{\text{ISL}} \theta$  (5)

Or  $\alpha$  is increasing with increasing  $\mu$ :

$\alpha_{\text{ISL}} > 0 \leftrightarrow \mu > w_{\text{ISL}} \theta$  and  $\mu > \theta^2 \lambda_{\text{ISL}}$ ;  $\alpha_{\text{ISL}} < 1 \leftrightarrow w_{\text{ISL}} > \theta \lambda_{\text{ISL}}$   
 $\partial \alpha_{\text{ISL}} / \partial \mu > 0 \leftrightarrow w_{\text{ISL}} > \lambda_{\text{ISL}} \theta$  (6)

Where:

$\partial \alpha_{\text{ISL}} / \partial \lambda_{\text{ISL}} > 0 \leftrightarrow \mu > w_{\text{ISL}} \theta$

Note that the first set of conditions (5) applies if  $\lambda_{\text{ISL}}$  is large (i.e., the use of the environment is technologically efficient) or if  $w_{\text{ISL}}$  is small (e.g., in a pre-industrial economy). In summary, an increase in  $\alpha$  implies an increase in  $(\lambda E)^\alpha$  and a decrease in  $(\mu/E)^{1-\alpha}$ : if  $\mu$  is small (e.g., with  $\mu < \lambda \theta^2$  at equilibrium for Islam), then the magnitude of the increase is larger than the magnitude of the decrease, so a smaller  $\mu$  is required to achieve the same  $w$  level. In other words, in terms of the likelihood of the second set of conditions (2, 4, 6) (i.e., for  $\alpha$  increasing with increasing  $\mu$ ),  $\text{HIN} > \text{JUD} > \text{ISL}$ , where condition 2 is met if  $m$  is large for HIN. Moreover, in terms of the likelihood of  $\alpha$  decreasing with decreasing  $\theta$  (i.e., stricter conditions in case of an increase in population),  $\text{HIN} = \text{ISL} > \text{JUD}$ . Finally, in terms of the minimum  $\mu$  in the case of an increasing  $\alpha$ ,  $\text{ISL} > \text{JUD} > \text{HIN}$ .

By comparing Hinduism and Judaism, one obtains  $\alpha_{\text{HIN}} = \alpha_{\text{JUD}}$  if  $\ln[\mu] \ln[m]$  equals  $2\ln[n](\ln[\theta] + \ln[\lambda] - \ln[w]) + \ln[m](2\ln[w] - 2\ln[n] - \ln[\lambda])$ . By comparing Judaism and

Islam, one obtains  $\alpha_{JUD} = \alpha_{ISL}$  if  $\ln[\mu] = \infty$  or if  $\ln[\mu] = 0$ . By comparing Hinduism and Islam, one obtains  $\alpha_{HIN} = \alpha_{ISL}$  if  $\ln[\mu] \ln[m]$  equals  $\ln[\lambda](-\ln[m] + \ln[w]) + (-\ln[\lambda] + 2\ln[m])\ln[w]$ . In other words, for a sufficiently large  $\mu$ , the  $\alpha$  for Hinduism and Buddhism is smaller than that for Judaism and Islam (i.e., it represents a stricter constraint on consumption). Moreover, if the second set of conditions applies to both Judaism and Islam, Judaism allows a larger  $\alpha$  than Islam (i.e., Judaism is less constrained than Islam). Finally, an increase in  $\lambda$  implies a larger  $\alpha$  for all religions (i.e., a looser constraint on consumption), provided the second set of conditions applies (i.e.,  $\alpha$  increasing with increasing  $\mu$ ).

## Appendix II: statistical results

In this section, I will estimate the significance and size of the impacts of the four main religious environmental ethics on sustainability by relying on the same dataset discussed in Section 3 (i.e., 145 countries) and the formulas introduced in Section 2.

**Table A1. Impacts of religious environmental ethics on EF (ecological footprint) (lnef in log), in addition to the per capita GDP (gross domestic product) (lngdp in log); budhin, isl, jud, chr are dummy variables identifying countries where Buddhism or Hinduism, Islam, Judaism, and Christianity are majority religions.**

| Source   | SS         | df  | MS         | Number of obs = 145 |        |  |
|----------|------------|-----|------------|---------------------|--------|--|
| Model    | 10.7474035 | 5   | 2.14948071 | F( 5, 139) =        | 97.20  |  |
| Residual | 3.07382149 | 139 | .022113824 | Prob > F =          | 0.0000 |  |
|          |            |     |            | R-squared =         | 0.7776 |  |
|          |            |     |            | Adj R-squared =     | 0.7696 |  |
| Total    | 13.821225  | 144 | .095980729 | Root MSE =          | .14871 |  |

| lnef   | Coef.     | Std. Err. | t      | P> t  | [95% Conf. Interval] |           |
|--------|-----------|-----------|--------|-------|----------------------|-----------|
| lngdp  | .4991936  | .0241188  | 20.70  | 0.000 | .4515065             | .5468807  |
| budhin | -.0644674 | .0638445  | -1.01  | 0.314 | -.1906993            | .0617645  |
| isl    | -.0384913 | .0420894  | -0.91  | 0.362 | -.1217096            | .044727   |
| jud    | .1084827  | .1536622  | 0.71   | 0.481 | -.1953348            | .4123002  |
| chr    | -.000919  | .0390526  | -0.02  | 0.981 | -.0781329            | .0762949  |
| _cons  | -1.557305 | .1013284  | -15.37 | 0.000 | -1.757649            | -1.356961 |

In particular, the formulas suggest the need to use a logarithmic transformation of dependent (i.e., ln EF) and independent (i.e., ln GDP) variables, and then to estimate a linear model. The dataset suggests a need to introduce dummy variables to identify countries where the majority of the population believes in a given religion (i.e., the number of Muslim, Buddhist or Hindu, Jewish, and Christian countries were 40, 8, 1, 83, respectively, with 13 countries that lack a majority religion), where the following Pearson's  $r$  values were observed for these dummy variables:  $r(\text{ISL, BUD/HIN}) = -0.15$ ,  $r(\text{ISL, JUD}) = -0.05$ ,  $r(\text{ISL, CHR}) = -0.65$ ,  $r(\text{BUD/HIN, JUD}) = -0.02$ ,  $r(\text{BUD/HIN, CHR}) = -0.28$ , and  $r(\text{JUD, CHR}) = -0.10$ . Note that using EF as a dependent variable implies that negative signs in the dummy variables mean a positive contribution of a religion to sustainability. In summary, if  $\mu$  is normalised to 1 for the sake of simplicity, I will estimate the following equation:

$$\ln EF = \alpha/(1 - \alpha) \ln GDP - \alpha/(1 - \alpha) \ln U + BUD/HIN + ISL + JUD + CHR + \xi$$

Where  $\xi$  are estimation residuals. Note that I expect a positive sign of the parameter attached to ln GDP, a negative constant, and a smaller value of the parameter attached to JUD, since  $\zeta = 1$  implies that, for Israel, ln U must be replaced by  $\ln U - \lambda \theta (1/\theta)^{1-\alpha}$ .

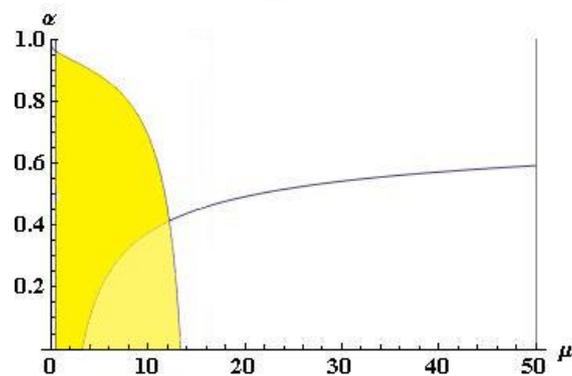
Estimation results are presented in Table A1.

Note that there is no religion with a negative sign that is both strong and significant. In other words, the positive analysis developed here (i.e., which religion favours sustainability) must be

coupled with the normative analysis developed in Section 4 (i.e., how religions should change to achieve sustainability). Moreover, the ranking presented in Section 4 is confirmed here, both in terms of size and significance: BUD/HIN > ISL > JUD > CHR. Finally, the statistical results confirm the theoretical insights on Judaism (i.e., a less negative impact on sustainability) and on Christianity (i.e., a non-significant impact on sustainability).

### Appendix III: sensitivity analyses

**Figure A1.** Comparison of the *feasibility* of religious environmental ethics for achieving sustainability, with  $n = 0.9$  (i.e., future population smaller than current population) and  $m = 5$  (i.e., a small dignity of non-human beings). For the parameter constraints,  $\mu \geq 58.4$  for Judaism (i.e., there are no feasible values of  $\mu$ ); for Islam,  $\mu \leq 13.3$ ; and for Hinduism or Buddhism,  $\mu \geq 3.2$ . Areas in the feasibility space: for Judaism, 0; for Islam (yellow and light yellow), 10.19; for Hinduism or Buddhism (light yellow and white area under the increasing curve), 22.79.



**Figure A2.** Comparison of the *effectiveness* of achieving sustainability based on religious environmental ethics (i.e., the potential of each religion to solve the same average global environmental problem), with  $n = 0.9$  (i.e., future population smaller than current population) and  $m = 5$  (i.e., a small dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 25.2$ ; for Islam,  $\mu \geq 22.6$ ; for Hinduism or Buddhism,  $\mu \geq 4.5$ . Areas in the feasibility space: for Judaism (light green area), 8.93; for Islam (yellow, light yellow, and light green areas), 11.95; for Hinduism or Buddhism (white area under the first increasing curve from the left, light yellow and light green areas), 19.07.

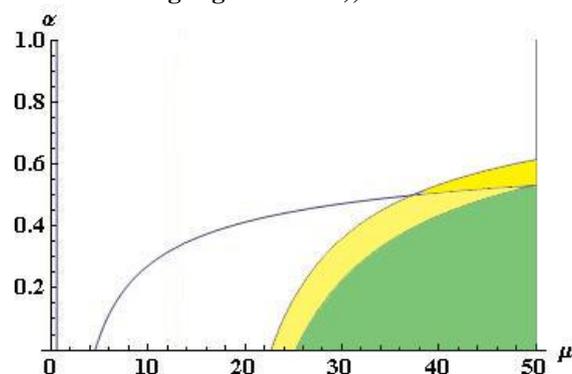


Figure A3. Comparison of the *replicability* of religious environmental ethics (i.e., potential of each religion to solve the same environmental problem in countries where the religion is a minority) for achieving sustainability in *pre-industrial* economies, with  $n = 0.9$  (i.e., future population smaller than current population) and  $m = 5$  (i.e., a small dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 14.7$ ; for Islam,  $\mu \leq 13.3$ ; for Hinduism or Buddhism,  $\mu \geq 2.6$ . Areas in the feasibility space: for Judaism (blue and light blue), 30.71; for Islam (yellow and light yellow), 11.91; for Hinduism or Buddhism (light yellow, light blue, and white area under the first increasing curve from the left), 26.03.

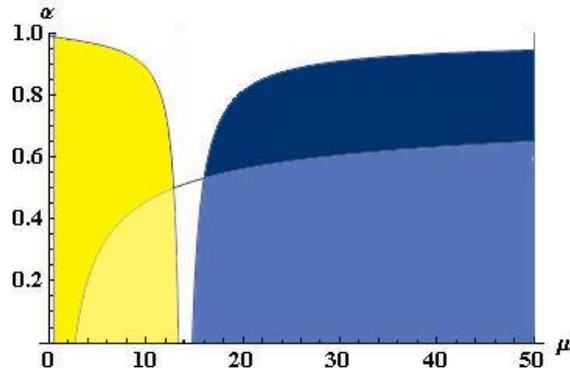


Figure A4. Comparison of the *replicability* of religious environmental ethics (i.e., potential of each religion to solve the same environmental problem in countries where the religion is a minority) for achieving sustainability in *industrial* economies, with  $n = 0.9$  (i.e., future population smaller than current population) and  $m = 5$  (i.e., a small dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 15.9$ ; for Islam,  $\mu \geq 17.7$ ; for Hinduism or Buddhism,  $\mu \geq 3.2$ . Areas in the feasibility space: for Judaism (blue and light blue, green and light green areas), 16.81; for Islam (green and light green areas), 20.49; for Hinduism or Buddhism (light green, light blue, and white area under the first increasing curve from the left), 22.29.

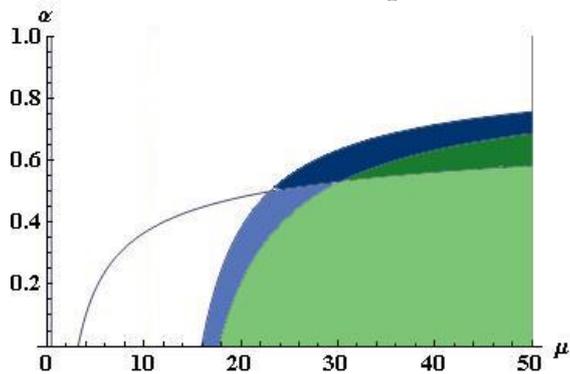


Figure A5. Comparison of the *replicability* of religious environmental ethics (i.e., potential of each religion to solve the same environmental problem in countries where the religion is a minority) for achieving sustainability in *post-industrial* economies, with  $n = 0.9$  (i.e., future population smaller than current population) and  $m = 5$  (i.e., a small dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 58.3$  (i.e., there are no feasible values of  $\mu$ ); for Islam,  $\mu \geq 52.5$  (i.e., there are no feasible values of  $\mu$ ); for Hinduism or Buddhism,  $\mu \geq 10.5$ . Areas in the feasibility space: for Judaism, 0; for Islam, 0; for Hinduism or Buddhism (white area under the increasing curve), 9.54.

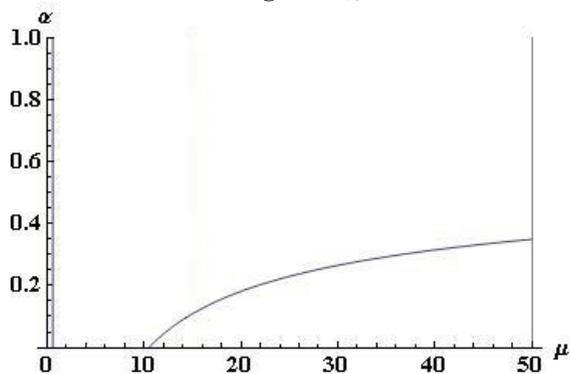


Figure A6. Comparison of the *replicability* of religious environmental ethics for achieving sustainability in *pre-industrial* economies, with  $n = 1.1$  (i.e., future population larger than current population) and  $m = 10$  (i.e., a large dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \leq 5.2$ ; for Islam,  $\mu \leq 5.7$ ; for Hinduism or Buddhism,  $\mu \geq 0.6$ . Areas in the feasibility space: for Judaism (green and light green areas), 2.82; for Islam (yellow and light yellow, green and light green areas), 3.38; for Hinduism or Buddhism (light green, light yellow, white area under the increasing curve), 31.38.

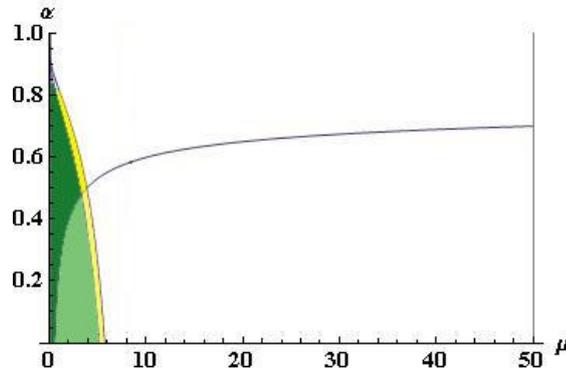


Figure A7. Comparison of the *replicability* of religious environmental ethics for achieving sustainability in *industrial* economies, with  $n = 1.1$  (i.e., future population larger than current population) and  $m = 10$  (i.e., a large dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 15.9$ ; for Islam,  $\mu \geq 17.5$ ; for Hinduism or Buddhism,  $\mu \geq 1.7$ . Areas in the feasibility space: for Judaism (blue and light blue, green and light green areas), 21.86; for Islam (green and light green areas), 18.23; for Hinduism or Buddhism (white area under the first increasing curve from the left, light blue and light green), 22.37.

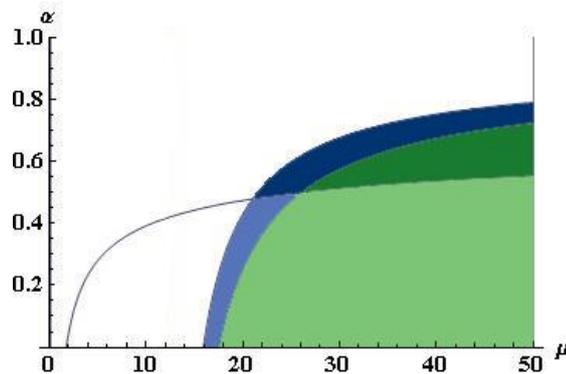
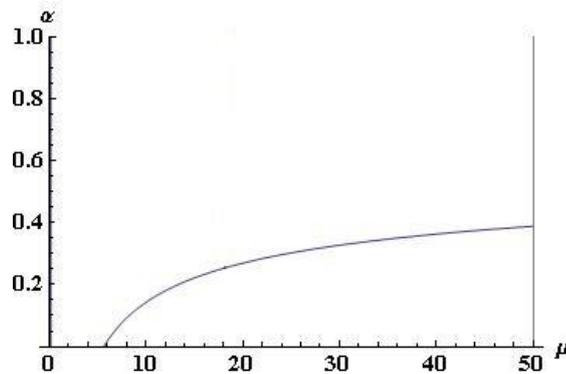


Figure A8. Comparison of the *replicability* of religious environmental ethics for achieving sustainability in *post-industrial* economies, with  $n = 1.1$  (i.e., future population larger than current population) and  $m = 10$  (i.e., a large dignity of non-human beings). Parameter constraints: for Judaism,  $\mu \geq 51.9$  (i.e., there are no feasible values of  $\mu$ ); for Islam,  $\mu \geq 56.3$  (i.e., there are no feasible values of  $\mu$ ); for Hinduism or Buddhism,  $\mu \geq 5.6$ . Areas in the feasibility space: for Judaism, 0; for Islam, 0; for Hinduism or Buddhism (white area under the increasing curve), 12.77.



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