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Multi-Criteria, Cost-Benefit, and Life-Cycle Analyses for Decision-Making to Support Responsible, Sustainable, and Alternative Tourism

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Abstract: This paper combines the most popular tourism typologies or goals (i.e., RT, responsible tourism, to represent impact minimisation; ST, sustainable tourism, to represent welfare maximisation; AT, alternative tourism, to represent continuity maximisation) and decision-making methodologies (i.e., MCA, multi-criteria analysis; CBA, cost-benefit analysis; WLCA, weighted life-cycle assessment; MLCA, monetary life-cycle assessment) in a single dynamic framework to operationally match the former with the latter. *Normative* insights show that MCA and WLCA are most suitable for RT and AT, respectively, whereas CBA and MLCA are most suitable for ST. Management *recommendations* (i.e., if a wrong static instead of a right dynamic approach must be adopted due to a lack of data, once chosen a tourism typology or goal, ST is the best in terms of level, correlation and likelihood of errors) are provided, and policy *recommendations* (i.e., if a right dynamic approach is adopted, in choosing among tourism typologies or goals, AT is the best in terms of precaution, ST is the best in terms of correlation, and RT is the best in terms of risk of investments) are suggested for a case study characterized by negative environmental and cultural dynamics. *Positive* insights show that two and many papers have applied WLCA and MLCA, respectively, to RT, but they did not account for cultural features; many papers have applied CBA to ST, but only one paper applied MLCA; few and no papers have applied MCA and WLCA, respectively, to AT.

Keywords: responsible tourism; sustainable tourism; alternative tourism; indicators; decision-making methods; planning and management; assessment methods

1. Introduction

Tourism typologies or goals such as "sustainable" tourism are meaningless if they do not provide indicators that can assess current or future scenarios and support the development of policies or projects. However, definitions and objectives drive the choice among the decision-making methodologies and indicators. Moreover, indicators depend on the definitions to be applied once a suitable decision-making methodology has been chosen. Finally, the policies or projects to be evaluated depend on the targets, and must be measured by indicators that are suitable for those objectives. Note that any approach to policies or projects requires a proper matching between definitions, goals, assessment methodologies, and indicators, whether in the context of the cooperative tools on a project basis that were endorsed by [1], the voluntary tools on a project basis supported by [2], the financing tools on a project basis for social responsibility supported by [3], or the market-based policies suggested by [4].

The purpose of the present study was to balance the perspectives of politicians [5] and researchers [6] by referring to the main concepts of sustainability science (i.e., impacts and continuity) and the main concepts of development politics (i.e., weak sustainability, a-growth, and strong sustainability) in order to *operationally* match the most popular tourism typologies or goals (i.e., RT, responsible tourism, to represent impact minimisation; ST, sustainable tourism, to represent welfare maximisation; AT, alternative tourism, to represent continuity maximisation) with suitable indicators, appropriate decision-making methodologies (cost-benefit analysis, CBA; multi-criteria analysis, MCA; weighted life-cycle assessment, WLCA; and monetary life-cycle assessment, MLCA), and suitable policies or projects. In order to do so, I use static concepts such as the objectives to be achieved (i.e., economic, social, environmental, and cultural targets) rather than dynamic concepts such as systems to be managed. I do not espouse any firm theory, although corporate social responsibility turns out to be close to weak sustainability in terms of how it assumes a combination of profit maximization with public sensitivity [7]. In addition, I do not adopt any specific growth theory, and instead adopt a local or regional planning approach (i.e., economic, social, environmental, and cultural investments). I do not refer to any consumption theory, although ethical consumption is close to RT and AT in its assumption that the objective is to drive public interventions towards sustainability [8]. In particular, I will suggest which decision-making methodologies should be implemented to assess each tourism typology or goal. I will highlight which data are needed to apply the *right* methodology (i.e., WLCA > MCA if the goal is to minimise impacts; MLCA > CBA if the goal is to maximise welfare; WLCA > MCA if the goal is to maximise continuity), and I will stress which errors (i.e., excessive or insufficient investments in environment or culture) result from applying the *wrong* static methodology (e.g., due to a lack of data) (Section 4.1) by emphasizing the likelihood of, and the correlation between, errors in the allocation of investments between environment and culture (i.e., their dependence and cross-dependence on the estimated environmental and cultural dynamics, respectively). I will highlight differences in investments when alternative *right* dynamic decision-making methodologies are used (Section 4.2) by emphasizing the precautionary characteristics of investment decisions (i.e., larger investments in environment or culture, leading to a greater likelihood of environmental and cultural preservation), the risk of, and the correlation between, investment decisions (i.e., higher sensitivity and cross-sensitivity to the estimated environmental and cultural dynamics, respectively). I will also estimate the impacts of policies on these differences in investments by emphasizing precaution, risk and correlation. Note that I will perform empirical comparisons of investment decisions based on a case study in Northern Italy if these comparisons cannot be carried out theoretically. In other words, identifying tourism typologies and goals will let me refer to goals to formalize the tourism typologies (Section 2) and obtain normative insights, and will let me refer to typologies to sort papers that have applied alternative assessment methodologies in the context of previous research results (Section 5) and obtain positive insights. Similarly, matching the goals with the appropriate assessment methodologies and indicators (i.e., static vs. dynamic indicators, independent vs. inter-dependent variables) will let me better define the tourism typologies. For example, if CBA is applied where positive environmental and cultural dynamics are observed, then ST is implicitly chosen in terms of its smaller risk, the larger precautionary component of the investment decisions, and in terms of its smaller correlation with dynamic variables. In summary, the following *management recommendations* will be provided: if choices are driven by data availability, CBA applied to ST should be preferred to MCA applied to RT and AT in terms of level, correlation and likelihood of errors; errors for AT show higher level and correlation, but smaller likelihood than RT. Next, a case study in Northern Italy, characterized by negative environmental and cultural dynamics, will suggest the following *policy recommendations*: if choices are driven by investment characteristics, AT estimated by WLCA should be preferred in terms of precaution, RT estimated by WLCA should be preferred in terms of risk, and ST estimated by MLCA should be preferred in terms of correlation of investments; investments for RT and AT show the same correlation and risk.

Note that all three tourism typologies emphasize stakeholder participation, although to different extents, so that market prices, as summary assessments of potentially conflicting interests and perceptions, must be replaced by alternative valuation procedures. For example, the analytic hierarchy process can be used to estimate relative weights or statistics can be used to estimate demand functions, with both methods accounting for the most representative stakeholders. Moreover, ST is close to weak sustainability, whereas RT and AT are closer to a-growth and strong sustainability, respectively, although with different goals and indicators. Finally, all four pillars of the analysis (economic, social, environmental, and cultural features) can be assessed by properly fine-tuning the four decision-making methodologies, so issues do not force a specified matching between the tourism typology and the analytical method. For example, income distribution effects that characterize RT or poverty alleviation effects that characterize AT could be estimated by CBA.

2. Definitions and Goals

In this section, I will discuss the main scientific and political concepts that underlie my analysis. I assume that the development of tourism opportunities will include both planning and management. In this paper, I will focus on developing tools to support planning and management of both existing and new tourism resources. Note that different stakeholders could have different objectives that must be accounted for in the decision-making process [9].

In the *scientific* literature, sustainability refers to "social and ecological resilience" [10], and the impacts and continuity are crucial aspects. In contrast, the United Nations Commission on Environment and Development (the Brundtland Commission) introduced the concept of sustainable development in 1987: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In this context, two concepts are crucial [11]: priority should be given to the essential needs of the world's poor (i.e., distributive justice in outcomes for current generations), and limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs should be stressed (i.e., technological and social innovation should be limited to the currently or imminently available technologies and organizations). By reframing this concept, *three* main sustainability paradigms have been suggested in the *policy* literature [12]. By replacing "needs" with "welfare", weak sustainability allows for natural resources to be depleted if this is compensated for by other resources (i.e., "development that allows the present generation to maximize its welfare without compromising the ability of future generations to maximize their own welfare"). By allowing for substitution between forms of capital to increase welfare, a-growth (i.e., an ecological and economic strategy based on indifference to or neutrality about economic levels and growth, with growth considered to be a non-robust and unreliable indicator of social welfare and progress) focuses on the many neglected non-market transactions (e.g., informal activities and relationships) and the many unpriced environmental effects. By aiming to preserve all separate species and resources, strong sustainability stresses that natural and physical or social capitals are complementary rather than interchangeable (i.e., "development that allows future generations to access to the same amount of natural resources and the same status of the environment as the current generation").

Note that weak sustainability is consistent with an economic general equilibrium framework, whereas strong sustainability is consistent with an ecosystem services framework. Moreover, de-growth (i.e., an ecological and economic perspective based on a socially sustainable and equitable reduction, and eventually stabilization, of the materials and energy that a society extracts, processes, transports, distributes, consumes, and returns back to the environment as waste) is irrelevant in a context of *planning* a (new) tourist destination to improve economic and social indicators such as income and employment. Finally, a-growth is consistent with an economic general equilibrium framework, provided that prices reflect the rights of all stakeholders.

I have made three main *contextual assumptions*. First, I will focus on four pillars of tourism sustainability (i.e., k = eco, soc, env, and cul, respectively, to depict economic, social, environmental, and cultural features). Indeed, since the relative weights of the four pillars must be based on stakeholder preferences, possible sub-features should be combined into the four pillar features to allow reliable estimation of preferences. Note that air and water quality (i.e., pollution) belong to the stock variable Y_{env} together with the features of the natural environment that can be enjoyed, such as vegetation and wildlife (i.e., renewable resources), or land, beaches, and mountains (i.e., non-renewable resources).

In contrast, historical and artistic monuments, dialects, traditions, arts, ceremonies, handicrafts, and museums are captured by the stock variable Y_{cul} together with the whole cultural heritage of the local community.

Second, environmental and cultural issues are affected over time by external factors that are not under the control of decision makers [13]. In particular, by defining the flow variables $X_k(t)$ as a change over time (t) in stock variables $Y_k(t)$ for pillar k, such that $\partial Y(t)/\partial t = X(t)$, I will refer to *positive* AR (1) (i.e., first-order autoregressive) dynamics to depict renewable resources (e.g., fish in a protected area), virtuous pollution reduction (e.g., a waste recycling system that improves behaviours), and cultural heritage (e.g., restored historical buildings, museums) for environmental and cultural issues, respectively:

$$X_k(t) = a\, X_k(t-1) + \eta_k(t) \text{ such that } X_k(T) = a^T\, X_k(0) + \sum a^{T-t}\, \eta_k(t) \quad (1)$$

where a represents the influence of the variable $X(t-1)$, with a one-period time lag, on its current value $X(t)$, where t represents the number of time periods since the start of the calculation; η represents unobservable random disturbances; T represents the planning and management horizon (in years); and 0 represents the start of the calculation period. In contrast, I refer to *negative* AR (1) dynamics to depict non-renewable resources (e.g., over-exploitation of a wild beach or mountain), vicious pollution reduction (e.g., a wastewater treatment plant that does not affect wasting behaviours), and cultural heritages (e.g., a commodification of traditional ceremonies or handicrafts) for environmental and cultural issues, respectively:

$$X_k(t) = a\, X_k(t-1) - \eta_k(t) \text{ such that } X_k(T) = a^T\, X_k(0) - \sum a^{T-t}\, \eta_k(t) \quad (2)$$

Indeed, alternative dynamics such as a positive MA (1) (i.e., first-order moving average) or a negative MA (1) would require a choice for $X_k(t)$ at each time t:

$$\text{Positive: } X_k(t) = \eta_k(t) + b\, \eta_k(t-1) \text{ such that } X_k(T) = \eta_k(T) + \sum b^t\, X_k(t) \quad (3)$$

$$\text{Negative: } X_k(t) = \eta_k(t) - b\, \eta_k(t-1) \text{ such that } X_k(T) = \eta_k(T) - \sum b^t\, X_k(t) \quad (4)$$

where b represents the influence of the disturbance $\eta(t-1)$ with a one-period time lag on the current value of the variable $X(t)$, where t represents the number of time periods since the start of the calculation.

Similarly, AR(1) with negative a or MA(1) with a positive b, such that $X(t)$ fluctuates over time, would require investment for odd values of T and no investment for even values of T, or vice versa. Therefore, four scenarios can be relevant in terms of environmental and cultural dynamics: increasing values of an environmental variable (e.g., additional fish in a lake, reduced amounts of un-recycled waste per tourist) and increasing values of a cultural variable (e.g., additional exhibitions in a cultural city); increasing values of an environmental variable and decreasing values of a cultural variable (e.g., loss of traditional ceremonies); decreasing values of an environmental variable (e.g., loss of wild forests) and increasing values of a cultural variable; and decreasing values of an environmental variable and decreasing values of a cultural variable. Note that I have assumed that the economic and social pillars are unaffected by external factors (i.e., I have adopted a ceteris paribus assumption for society and the economy).

Third, all control variables (i.e., a change in the value of flow variables at a given time, $\Delta X_k(t)$) are defined as beneficial but expensive features (i.e., X_k represents a feature that increases welfare but that requires investments). In particular, ΔX_{eco} and ΔX_{soc} depict investments in economic and social features, respectively; ΔX_{env} depicts an increase and an investment in (stock) renewable or non-renewable resources and a reduction in pollution, whereas ΔX_{cul} depicts an increase and an investment in (stock) cultural heritage. Note that policies can be depicted by a change in control variables (e.g., as investments to fill the gap between the current and desired stocks) or by a change in parameter values (e.g., as unitary costs or relative concerns).

I made three main *simplifying assumptions*. First, investment costs are borne at time 0 by observing the values of the variables at time 0. This implies that I will use only the inter-temporal utility discount factor ρ applied by ST instead of the monetary discount rate, whereas discounting is not used for RT and AT. In particular, economic and social variables are assumed to be 0 at time 0 (i.e., they represent a baseline value against which future values are compared), whereas environmental and cultural variables could be different from 0 because they are dynamic rather than static variables. Second, benefits from expenditures are perceived at time 1 and subsequent times, whereas economic and social effects do not change over time (i.e., they are the same as at time 1), and environmental and cultural effects follow the dynamics specified above:

$$X_{\text{eco}}(t) = X_{\text{eco}}(1) \text{ and } X_{\text{soc}}(t) = X_{\text{soc}}(1) \text{ for each } t \geq 1 \quad (5)$$

Third, the planning and management time horizon is fixed at T, where environmental and cultural variables achieve their long-run equilibrium. In other words, I focus on external impacts on the natural environment or cultural heritage (e.g., over-exploitation of natural resources or commodification of traditional ceremonies) rather than on external impacts on economic or social features (e.g., cost of living, traffic congestion). Note that alternative contexts would not produce additional insights. For instance, if costs must be borne at each time t to maintain the beneficial effects of both constant (i.e., economic and social) and dynamic (i.e., environmental and cultural) variables, the budget constraint must include a discount rate, where additional savings or investments can only be magnified. Moreover, the stock variable $Y(t)$ can only be positive or 0 (i.e., it can be exhaustible or not). Finally, dynamic data might be required to estimate η_k. For instance, the number of people employed in producing traditional handicrafts at some time after the start of the study period would let us estimate the dynamics of $X_{\text{cul}}(t)$.

Sections 2.1–2.3 will characterize the three tourism typologies by formalizing them as a single goal within a single framework, whereas Section 2.4 will provide a conceptual reference of the three tourism typologies to be used in subsequent sections. Note that Gossling et al. [14] compared optimisation of many features with maximisation of a single feature; however, they focused only on economic issues. Moreover, tourism goals could be combined by considering impact minimisation together with welfare maximisation or continuity maximisation together with welfare maximisation. See Appendix A for feasible analytical solutions in this context. Finally, Prince and Ioannides [15] suggested management strategies to bridge AT with ST; indeed, tourism goals could be combined by analysing or planning different goals during different periods.

2.1. Responsible Tourism (RT): Minimizing Impacts

The United Nations Educational, Scientific and Cultural Organization (UNESCO) [16] identified the following *main* (local) features of RT:

- Minimise negative environmental and cultural impacts;
- Enhance the well-being of the host communities;
- Conserve natural and cultural heritage;
- Improve access for physically challenged people.

Mathematically, we choose values of $X_{\text{env}}(t)$ and $X_{\text{cul}}(t)$ in order to:

$$\text{Min} \sum_{t=1}^{T} w_{\text{env}} \left[X_{\text{env}}(t) - X_{\text{env}}(0)\right]^2 + w_{\text{cul}} \left[X_{\text{cul}}(t) - X_{\text{cul}}(0)\right]^2 \quad (6)$$

where w_{env} represents the weight of environmental values and w_{cul} represents the weight of cultural values, s.t.

$$c_{\text{eco}} \left[X_{\text{eco}}(t) - X_{\text{eco}}(0)\right] + c_{\text{soc}} \left[X_{\text{soc}}(t) - X_{\text{soc}}(0)\right] + c_{\text{env}} \left[X_{\text{env}}(t) - X_{\text{env}}(0)\right] + c_{\text{cul}} \left[X_{\text{cul}}(t) - X_{\text{cul}}(0)\right] \leq Z$$

$$X_{eco}(t) - X_{eco}(0) \geq 0,\ X_{soc}(t) \geq X_{socrt},\ \text{Sup}\ X_{env} \geq X_{env}(t) \geq \text{Inf}\ X_{env},\ \text{Sup}\ X_{cul} \geq X_{cul}(t) \geq \text{Inf}\ X_{cul}$$

where c_{eco}, c_{soc}, c_{env}, and c_{cul} represent the unitary costs of economic, social, environmental, and cultural investments, respectively; Z represents the budget constraint; X_{socrt} is the minimum level of social indicators to represent equity concerns; Sup and Inf depict the supremum and the infimum values of the flow variables, respectively; and w_{env} represents the largest relative weight.

Additional features of RT, such as the need to involve local people in decision-making or to provide meaningful connections between tourists and local people [17] are not formalised and discussed in the rest of my analysis.

Note that carrying capacity (e.g., [18,19]) is a similar concept, but with the emphasis placed upon resources or product life cycles or communities [20]. Moreover, responsible tourism resembles green tourism, social tourism, and volunteer tourism (e.g., [21]). Finally, the following tourism policies could be suggested for responsible tourism: protect land or sea areas [22]; improve relationships with social and regulatory stakeholders, effective management of human resources, market standing, operational efficiency, cost savings, and poverty alleviation [23]; and improve working conditions, promote cultural heritage, and involve local communities [24].

2.2. Sustainable Tourism (ST): Maximizing Welfare

The World Tourism Organization (UNWTO) [25,26] identified the following *main* (regional) features of ST:

- Meet the economic and social needs of present tourists and their host regions;
- Maintain cultural integrity, essential ecological processes, biological diversity and life-support systems to protect and enhance future opportunities.

Additional features of ST, such as the ability to attain long-run integration of economic, social, and environmental targets [27] are also formalised.

Mathematically, we choose values of $X_{eco}(t)$, $X_{soc}(t)$, $X_{env}(t)$, and $X_{cul}(t)$ in order to:

$$\text{Max} \sum_{t=1}^{T} (1/(1+\rho)^t)\,[X_{eco}(t) - (1/2)\,p_{eco}\,X_{eco}(t)^2 + X_{soc}(t) - (1/2)\,p_{soc}\,X_{soc}(t)^2 + X_{env}(t) - (1/2)\,p_{env}\,X_{env}(t)^2 + X_{cul}(t) - (1/2)\,p_{cul}\,X_{cul}(t)^2] \quad (7)$$

where ρ represents the inter-temporal utility discount factor; and p_{eco}, p_{soc}, p_{env}, and p_{cul} depict the concavity of the quadratic utility function for the economic, social, environmental and cultural items, respectively, s.t.

$$c_{eco}\,[X_{eco}(t) - X_{eco}(0)] + c_{soc}\,[X_{soc}(t) - X_{soc}(0)] + c_{env}\,[X_{env}(t) - X_{env}(0)] + c_{cul}\,[X_{cul}(t) - X_{cul}(0)] \leq Z$$

$$X_{eco}(t) - X_{eco}(0) \geq 0,\ X_{soc}(t) - X_{soc}(0) \geq 0,\ X_{env}(t) - X_{env}(0) \geq 0,\ X_{cul}(t) - X_{cul}(0) \geq 0$$

where $X_{eco}(t) = X_{eco}(1)$ and $X_{soc}(t) = X_{soc}(1)$ for each $t \geq 1$.

Note that sustainable hospitality [11] is a narrower concept, although ST is meaningless unless it is included within the broader context of sustainable development [28]. Moreover, sustainable tourism may include eco-tourism, mountain tourism, indigenous tourism, and rural tourism [29]. Finally, the following tourism policies could be suggested for sustainable tourism: cooperative tools on a project basis, such as dissemination of information by conferences, networking, technical assistance or cooperation, and capacity building by creating awareness and knowledge [1]; voluntary tools on a project basis, such as technical reports on best practices and policy recommendations and project financing [2]; financing tools on a project basis for social responsibility, market competition, quality perception, and technological innovation, such as COM(2003)716 "Basic orientations for the sustainability of European tourism", COM(2007)621 "Agenda for a sustainable and competitive European tourism", COM(2010)352 "Europe, the world's No. 1 tourist destination: a new political framework for tourism in Europe"; and market-based instruments, such as fiscal incentives (e.g., tax relief, grants, matching funding) or benefits in kind [4].

2.3. Alternative Tourism (AT): Maximizing the Continuity

UNWTO [30] identifies the following *main* (local) features of AT:

- Maintain ancestral cultures;
- Preserve nature;
- Alleviate poverty.

Mathematically, we choose values of $X_{\mathrm{env}}(t)$ and $X_{\mathrm{cul}}(t)$ in order to:

$$\mathrm{Min} \sum_{t=1}{}^{T} w_{\mathrm{env}} \left[X_{\mathrm{env}}(t) - X_{\mathrm{env}}(T)\right]^2 + w_{\mathrm{cul}} \left[X_{\mathrm{cul}}(t) - X_{\mathrm{cul}}(T)\right]^2 \quad (8)$$

s.t.

$$c_{\mathrm{eco}} \left[X_{\mathrm{eco}}(t) - X_{\mathrm{eco}}(0)\right] + c_{\mathrm{soc}} \left[X_{\mathrm{soc}}(t) - X_{\mathrm{soc}}(0)\right] + c_{\mathrm{env}} \left[X_{\mathrm{env}}(t) - X_{\mathrm{env}}(0)\right] + c_{\mathrm{cul}} \left[X_{\mathrm{cul}}(t) - X_{\mathrm{cul}}(0)\right] \leq Z$$

$$X_{\mathrm{eco}}(t) - X_{\mathrm{eco}}(0) \geq 0,\ X_{\mathrm{soc}}(t) \geq X_{\mathrm{socat}},\ \mathrm{Sup}\ X_{\mathrm{env}} \geq X_{\mathrm{env}}(t) \geq \mathrm{Inf}\ X_{\mathrm{env}},\ \mathrm{Sup}\ X_{\mathrm{cul}} \geq X_{\mathrm{cul}}(t) \geq \mathrm{Inf}\ X_{\mathrm{cul}}$$

where X_{socat} is the minimum level of social indicators to represent equity concerns, with w_{cul} being the largest relative weight. Additional features of AT, such as small-scale and locally controlled decisions or tight interactions between tourists and the host population [15], are not formalised and discussed in the rest of my analysis.

Note that the "three bottom lines" is a similar concept, in which all features must be larger than a given threshold [24]. Moreover, alternative tourism resembles geo-tourism, backpacking tourism, homestay (e.g., [31]), gastronomic tourism (e.g., [32]), cycling charity tourism (e.g., [33]), and reality tourism (e.g., [34]). Finally, the following tourism policies could be suggested for alternative tourism: recovery of ceremonies or craftsmanship, restoration of historical buildings or artistic sites, preservation of natural resources and of ancestral cultures, sharing of tourism revenues and access to resources, and relying on typical product–territory relationships such as olive oil or wine production. Yang et al. [35] provide a framework for an LCA application to identify the long-run equilibrium in carrying capacity; Hernandez and Leon [36] provide a predator–prey model to identify the long-run equilibria in physical infrastructure and natural capital; and Albaladejo and Martinez-Garcia [37] provide an endogenous growth model to identify the long-run equilibrium in carrying capacity.

2.4. A Conceptual Reference

Table 1 summarizes the main characteristics of the three tourism typologies in a single framework based on the main institutional references: all four pillars are assumed to be present in all tourism typologies, although with differences in their relative importance (although the social feature is never the main feature); and all three typologies are assumed to have different goals, with RT and AT having a primarily local perspective, whereas ST has a primarily regional perspective. Note that I have associated the goals, main features, and perspectives with a tourism typology to simplify the discussion of the insights presented in the rest of the paper.

Table 1. A conceptual reference for the main characteristics of the tourism typologies.

	Responsible Tourism	**Sustainable Tourism**	**Alternative Tourism**
Goal	Minimize impacts	Maximize welfare	Maximize continuity
Main feature	Environment	Economy	Culture
Perspective	Local and action-oriented	Regional and industry-centred	Local and conservation-oriented
Policies	Protect natural areas, improve working conditions	Fund sustainability projects, subsidize sustainable firms	Recover ceremonies or craftsmanship, restore historical buildings or artistic sites
Forms	Green, social, volunteer	Eco-tourism, rural, mountain, indigenous	Geo-tourism, backpacking, homestay, gastronomic, cycling, charity, reality
Ethics	Aristotle	Bentham	Kant
Focused issues	Sustained economic community development without compromising the existing resources for future generations Distributive justice (e.g., disadvantaged and poor people)	Human welfare (e.g., income and employment) & sustained yield of resources deriving from the governance of populations and ecosystems Structural inequalities (e.g., gender, poverty)	Sustained ecosystem biodiversity of individual species in ecosystems used by humans Procedural justice (e.g., hosts & tourists as actors)
Missed issues	Planning and management Global and long-run landscape Hosts and tourists as actors	Long-run landscape Culture-nature relations with allowed substitutions between capitals Host and tourists as actors	Global landscape Planning and management

Note that the planning context suggests that we can disregard cross-country differences in the impacts of inbound and outbound tourisms. Qureshi et al. [38] provide an econometric model of these impacts. Moreover, I will estimate the policy impacts by disregarding issues of policy integration. Aall et al. [39] discuss policy integration based on coordination, harmonization, and prioritization as well as based on inclusion, consistency, priorities, and reporting. Finally, the planning context suggests that we can disregard the impacts of sustainability on competitiveness. Pulido-Fernandez et al. [40] provide a cross-country analysis of these impacts.

3. Decision-Making Methodologies and Indicators

In this section, I will discuss assessment methodologies and indicators. For the assessment methodologies, I will focus on MCA (i.e., a decision-making tool for selecting projects, where many objectives and criteria are estimated in percentages and combined by using relative weights), CBA (i.e., a set of rules for the economic evaluation of alternative projects, where the aim is to maximise the social welfare by maximising the net social benefits for a referent group of people), WLCA (i.e., an assessment method for selecting products, where material extraction, construction process, maintenance and operation, and recycling upon life cycle completion are evaluated in terms of possible incompatible criteria and then combined by using relative weights), and MLCA (i.e., an assessment method for selecting products, where material extraction, construction process, maintenance and operation, and recycling upon life cycle completion are evaluated in terms of materials or energy) [12] by considering environmental impact analysis (e.g., [41]) as a simple case of MCA, and cost-effectiveness analysis (e.g., [42]) as a simple case of CBA. Arcese et al. [43] provide a methodological discussion of WLCA applied to tourism, whereas Scheepens et al. [44] provide an empirical validation of MLCA for water tourism based on a cost-efficient value creation method. Table 2 summarises the main strengths and weaknesses of the four assessment methodologies with reference to tourism planning and management. For the indicators, I will identify suitable indicators by assuming consensus among stakeholders. Mihalic [45], Torres-Delgado and Palomeque [46], Torres-Delgado and Saarinen [47], Iliopoulou-Georgudaki et al. [48], Lee and Hsieh [49], Wang et al. [50], Hashemi and Ghaffary [51], and Onder et al. [52] review this subject.

Note that I will not discuss how to integrate indicators with decision-making [53]. Moreover, I will not discuss the technicalities required to produce the indicators, such as entropy analysis [54], neural networks [55], and factor analysis [56]. Finally, I will not discuss how to scale the indicators ([57–59]) or how to weight the indicators ([48–51]).

I have made three main *contextual assumptions*. First, I will represent potential conflicts between tourists and their hosts by assuming that the interests of tourists are well represented by X_{eco} (i.e., the willingness to pay of tourists is totally translated into the economic benefits for their hosts). Alternatively, I could have introduced a maximum threshold for conflicts as perceived by tourists or locals, and objectively estimated that threshold in non-monetary terms (e.g., the percentage of tourists willing to come back; the percentage of locals who support tourism development). Hunt and Stronza [60] describe the estimation of resident attitudes towards tourists. Second, I have assumed that there is no tragedy of the commons. In other words, I will assume a participatory planning context by excluding resources that could be appropriated by certain stakeholders, thereby alienating other stakeholders from the use of those resources. Third, I will represent the potential conflicts (e.g., conflicts over the distribution of tourism revenues) between hosts by modifying X_{soc} (e.g., increasing the minimum X_{soc}, thereby reducing inequality in X_{soc}). Note that I will not discuss how to control institutions (e.g., trust, networks, local control; [61]) or to govern institutions (e.g., community-based vs. lease-operation tourism; [62]).

Table 2. Summary of strengths and weaknesses of multi-criteria analysis (MCA), cost-benefit analysis (CBA), weighted life-cycle assessment (WLCA), monetary life-cycle assessment (MLCA) with reference to tourism planning and management.

	Strengths	**Solvable/Practical Weaknesses**	**Unsolvable/Theoretical Weaknesses**
MCA	Applicable to products and destinations Combination of many features	Qualitative evaluations	Decisions depend on weight assessment and criteria combination methodologies Local and short-run approach
CBA	Reference to competitive general equilibrium Applicable to products and destinations	Distributional issues Risk Indirect impactsLocal and short-run approach Lack of data for quantifying benefits and costs	Attempt to evaluate in monetary terms also intangible features
WLCA	Global and long-run approach Combination of many features Applicable to products	Validation and robustness of results Social issues	Inapplicable to destinations Decisions depend on weight assessment and criteria combination methodologies Lack of referent standards for the evaluation
MLCA	Global and long-run approach Applicable to products	Validation and robustness of results Lack of data for quantifying energy and materials	Inapplicable to destinations Attempt to evaluate everything in energy or material terms Social issues

I have made three main *simplifying assumptions*. First, I have assumed piece-wise linear dynamics; that is, I have assumed the same η for a given range of t values (i.e., $\eta \neq 0$ for $t \leq$ some reference t and $\eta = 0$ for $t >$ the same reference t). Hereafter, I will use η to represent the dynamics of the environmental or cultural indexes, where it represents the rate of increase in the initial value per year. Smooth (rather than piece-wise) nonlinear dynamics (e.g., $X(t) = X(0) \times \exp[-\eta\ t]$) would only affect the final T. In other words, I disregard seasonality issues ([63–65]).

Second, I will assume a non-stationary random walk (i.e., $a = 1$ and $X(t) = X(0) + \eta\ t$). If $a < 1$, this would only affect the final T. In particular, the case of $\eta > 0$ depicts a renewable resource, net of its use at time t, or the virtuous reduction of pollution, net of its production at time t, towards the resource's maximum or long-run stable equilibrium level (i.e., $X(T) = \max X = X(0) + \eta\ T$). In contrast, the case of $\eta < 0$ depicts a non-renewable resource, net of its use at time t, or the vicious reduction of pollution, net of its production at time t, towards the resource's minimum or long-run stable equilibrium level (i.e., $X(T) = \min X = X(0) + \eta\ T$). The case of $\eta = 0$ depicts an economic or social variable that produces a constant benefit for each time $t \geq 1$ (e.g., a new hotel ensures a given income and employment levels for each year or other period after it opens). Note that the relevant time horizon for planning is determined by the environmental or cultural effects characterized by the smallest T; this is similar to an analysis of competing carrying capacities [66], although it is based on the dynamics of external variables that affect tourism rather than on the number of tourists.

Third, I will standardize the flow of resources with respect to the maximum level of flows for each dynamic variable (i.e., Sup $X_k = 1$). In particular, investments could generate economic or social impacts that are constant in time, such as income ($X_{eco} \leq 1$) or employment ($X_{soc} \leq 1$). In addition, investments could generate environmental impacts that vary over time, such as increasing renewable resources or pollution production and decreasing non-renewable resources or waste production ($X_{env}(t) \leq 1$) and cultural impacts that vary over time, such as increasing the social fabric or cultural buildings, or decreasing cultural heritage ($X_{cul}(t) \leq 1$).

Figure 1 depicts the resulting dynamics for environmental and cultural features affected by positive and negative external factors, whereas Figure 2 represents the resulting dynamics for economic and social features.

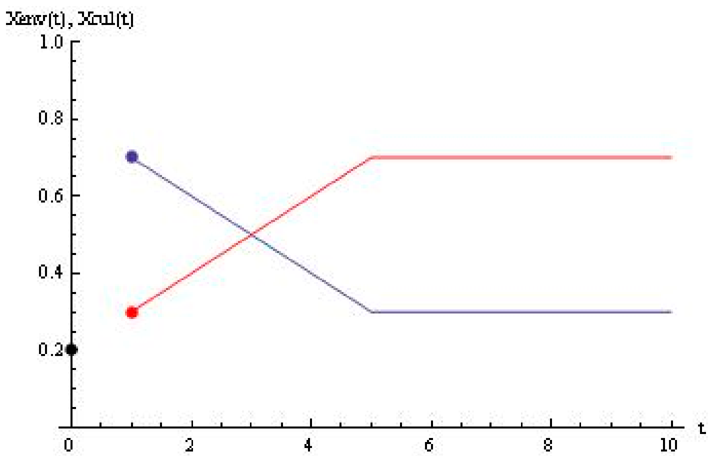

Figure 1. Dynamics of environmental and cultural features towards the long-run resource's maximum in the case of *positive* external factors from time (t) 1 to 10 (red). For example, environmental investments (e.g., a natural protected area, a virtuous waste recycling system) and cultural investments (e.g., restoration of historical buildings) increased from 0.2 (black) at time 0 to 0.3 (red) at time 1. Dynamics of environmental and cultural features towards the long-run resource's minimum in the case of *negative* external factors from time (t) 1 to 10 (blue). For example, environmental investments (e.g., restoration of a natural beach, a vicious waste recycling system) and cultural investments (e.g., restoration of traditional ceremonies) increased from 0.2 (black) at time 0 to 0.7 (blue) at time 1.

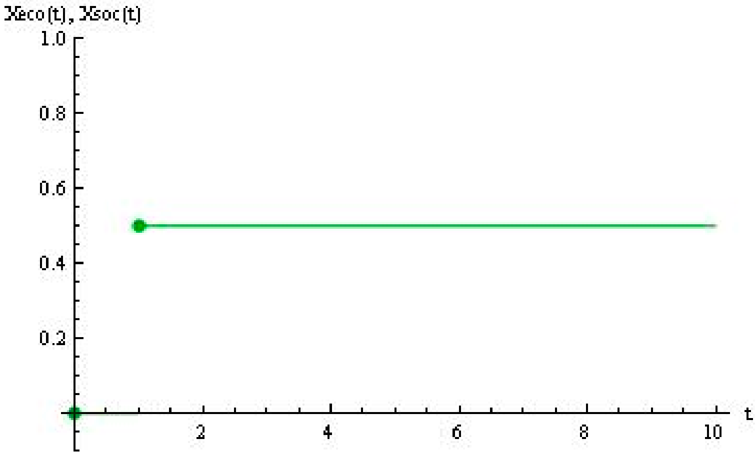

Figure 2. Dynamics of economic and social features (green). For example, investments in economic features (e.g., hotel capacity) and social features (e.g., hotel employment) increased from 0 at time 0 to 0.5 at time 1.

I made three main *simplifying standardizations*. First, in ST, I will assume an attitude of risk neutrality towards economic issues; in other words, I will standardize the marginal utility of money to 1 (i.e., $1 - p_{eco} = 1$, so that $p_{eco} = 0$). This implies that $c_{eco} = 1 + \rho$ at equilibrium. Moreover, I assumed that the marginal utility at Sup X_k and Inf X_k is 0 (i.e., $1 - p_k$ Sup $X_k = 0$ and $1 - p_k$ Inf $X_k = 0$) so that $p_k = 1/\text{Sup } X_k$ and $p_k = 1/\text{Inf } X_k$. Finally, in RT and AT, I will focus on solutions for the dynamic environmental and cultural variables, whereas solutions for economic and social variables come from meeting the static economic and social constraints and targets, respectively. In particular, I will not focus on long-run equilibria or on their stability conditions (i.e., X_{env} or X_{cul} could be unstable if X_{env} < Inf X_{env} or X_{cul} < Inf X_{cul} move tourists to other destinations, and if it takes long time to restore both X_{env} and X_{cul}), but I will focus on paths towards long-run equilibria from above or from below. Indeed, my purpose is to identify differences in investment decisions based on alternative assessment methodologies: assuming a jump to the long-run equilibria would be meaningless for this purpose. Supplemental Material I summarizes the main simplifying assumptions.

3.1. Multi-Criteria Analysis (MCA) vs. Weighted Life-Cycle Assessment (WLCA) for RT

The dynamic RT solutions with WLCA can be described as follows:

$$\begin{aligned} X_{env} = \; & \#\{2c_{env}{}^2 p_{cul} p_{soc} w_{cul} - 2c_{env}{}^3 p_{cul} p_{soc} w_{cul} \\ & + c_{env} p_{env} w_{cul} [-2c_{soc}{}^2 p_{cul} - 2c_{soc} p_{cul}(-1 + p_{soc} X_{soc}) \\ & + c_{cul} p_{soc}(2 - 2c_{cul} - 2p_{cul} X_{cul}(0) + \eta_{cul} T p_{cul} \theta_{cul})] \\ & + c_{cul}{}^2 p_{cul} p_{env} p_{soc} w_{env}(4X_{env}(0) - \eta_{env} T \theta_{env})\} \end{aligned} \quad (9)$$

where,

$$\# = 1/\left[2p_{cul} p_{env} p_{soc}\left(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env}\right)\right]$$

and $\theta_{env} = 1$ and $\theta_{cul} = 1$ depict positive and consonant environmental and cultural dynamics, $\theta_{env} = -1$ and $\theta_{cul} = -1$ depict negative and consonant environmental and cultural dynamics; and similarly for dissonant dynamics (i.e., dynamics in which θ_{env} and θ_{cul} have different signs).

$$\begin{aligned} X_{cul} = \; & \#\{2c_{cul}{}^2 p_{env} p_{soc} w_{env} - 2c_{cul}{}^3 p_{env} p_{soc} w_{env} \\ & + c_{env}{}^2 p_{cul} p_{env} p_{soc} w_{cul}(2X_{cul}(0) - \eta_{cul} T \theta_{cul}) \\ & + c_{cul} p_{cul} w_{env} [-2c_{soc}{}^2 p_{env} - 2c_{soc} p_{env}(-1 + p_{soc} X_{soc}) \\ & + c_{env} p_{soc}(2 - 2c_{env} - 4p_{env} X_{env}(0) + \eta_{env} T p_{env} \theta_{env})]\} \end{aligned} \quad (10)$$

Next, we can calculate the dynamic RT monetary solutions based on the assumption that $c_k = w_k$:

$$\begin{aligned} X_{env} = \ & \S\{-2c_{soc}{}^2 p_{cul} p_{env} - 2c_{soc} p_{cul} p_{env}(-1 + p_{soc} X_{soc}) \\ & + p_{soc}[2c_{env} p_{cul} - 2c_{env}{}^2 p_{cul} \\ & + c_{cul} p_{env}(2 - 2c_{cul} \\ & + p_{cul}(-2X_{cul}(0) + 4X_{env}(0) + \eta_{cul} T\theta_{cul} \\ & - \eta_{env} T\theta_{env}))]\} \end{aligned} \tag{11}$$

where,

$$\S = 1/[(c_{cul} + c_{env}) p_{cul} p_{env} p_{soc}]$$

and

$$\begin{aligned} X_{cul} = \ & \S\{-2c_{soc}{}^2 p_{cul} p_{env} - 2c_{soc} p_{cul} p_{env}(-1 + p_{soc} X_{soc})\} \\ & + p_{soc}[-2c_{env}{}^2 p_{cul} - 2(-1 + c_{cul}) c_{cul} p_{env} \\ & + c_{env} p_{cul}(2 + p_{env}(2X_{cul}(0) - 4X_{env}(0) - \eta_{cul} T\theta_{cul} \\ & + \eta_{env} T\theta_{env} \end{aligned} \tag{12}$$

In other words, if WLCA is applied, the chosen X_{env} (i.e., X_{env}*) increases with respect to $X_{env}(0)$. That is, a larger initial environmental resource implies a larger investment in the environment:

$$\partial X_{env}^*/\partial X_{env}(0) = 2\, c_{cul}{}^2\, w_{env}/(c_{env}{}^2\, w_{cul} + c_{cul}{}^2\, w_{env}) \tag{13}$$

X_{env}* decreases with respect to $X_{cul}(0)$. That is, with a fixed budget for a given planning period, a larger initial cultural heritage implies a smaller investment in the environment:

$$\partial X_{env}^*/\partial X_{cul}(0) = -c_{cul}\, w_{env}\, c_{env}/(c_{env}{}^2\, w_{cul} + c_{cul}{}^2\, w_{env}) \tag{14}$$

X_{env}* decreases with respect to X_{socrt}. That is, reducing social inequality implies a reduction of environmental investments:

$$\partial X_{env}^*/\partial X_{socrt} = -c_{soc}\, w_{cul}\, c_{env}/(c_{env}{}^2\, w_{cul} + c_{cul}{}^2\, w_{env}) \tag{15}$$

Similar results are obtained if MLCA is applied, where these partial derivatives become $2\, c_{cul}/(c_{cul} + c_{env})$, $-c_{cul}/(c_{cul} + c_{env})$, and $-c_{soc}/(c_{cul} + c_{env})$, respectively. The same results, with appropriate changes in the variable names, can be obtained for cultural investment decisions.

In particular, RT solutions with WLCA depend on T as follows:

$$\frac{\partial X_{env}}{\partial T} = \frac{c_{cul} c_{env} \eta_{cul} w_{cul} \theta_{cul} - c_{cul}{}^2 \eta_{env} w_{env} \theta_{env}}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})} \tag{16}$$

and,

$$\frac{\partial X_{cul}}{\partial T} = \frac{c_{cul} c_{env} \eta_{env} w_{env} \theta_{env} - c_{env}{}^2 \eta_{cul} w_{cul} \theta_{cul}}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})} \tag{17}$$

Thus, T can positively and negatively affect both investment decisions, although with an opposite sign, with the magnitude of the effect depending on the unit costs and relative weights.

Next, RT solutions with MLCA depend on T as follows:

$$\frac{\partial X_{env}}{\partial T} = \frac{c_{cul}(\eta_{cul}\theta_{cul} - \eta_{env}\theta_{env})}{2(c_{env} + c_{cul})} \tag{18}$$

and

$$\frac{\partial X_{cul}}{\partial T} = \frac{c_{env}(\eta_{env}\theta_{env} - \eta_{cul}\theta_{cul})}{2(c_{env} + c_{cul})} \tag{19}$$

Thus, a longer time horizon (T) negatively affects environmental investment decisions if the dynamics are dissonant (i.e., $\theta_{env} = 1$ and $\theta_{cul} = -1$) and if the cultural dynamic is smaller than the environmental dynamic (i.e., $\eta_{cul} < \eta_{env}$). We obtain similar results for the cultural investment decision X_{cul}* if we apply the same partial derivatives to it. The right approach for RT is WLCA whenever environmental and cultural dynamics are not negligible.

Many indicators in the literature seem to be suitable for a dynamic assessment of the *crucial* environmental dimensions of RT [67]. For instance, Navarro Jurado et al. [18] identify aspiration levels, reservation levels, and ranges of some ecological indicators (e.g., beach stability, beach quality, a morphodynamic index, the wealth landscape, built-up areas in the first kilometre of coastal strip, vegetation, fauna) that seem to be close to the X_{env}, minimum X_{env}, and maximum X_{env}–minimum X_{env} that I applied here. Next, Blancas et al. [68] suggest indicators for the environmental dimension of tourism, for both the assessment (e.g., energy intensity or water consumption attributable to tourism) and management or development of policies (e.g., percentage of the destination's surface considered to be a protected natural area, number of urban wastewater treatment plants per 1000 inhabitants).

3.2. Cost-Benefit Analysis (CBA) vs. Monetary Life-Cycle Assessment (MLCA) for ST

The dynamic ST solutions can be described as follows, based on my assumption that, for each k, the marginal utility equals the marginal cost ($1 - p_k X_k = c_k$):

$$X_k = \frac{1 - c_k(1+\rho)}{p_k} - \frac{T\theta_k\eta_k}{2} \leq \frac{1}{p_k} \tag{20}$$

In words, the chosen X_k (i.e., X_k*) decreases with increases in the inter-temporal utility discount factor ρ (i.e., the discounted value of benefits achieved tomorrow will be smaller than the current costs borne today); X_k* also decreases with increasing T if a positive dynamic applies (i.e., $\theta_k > 0$), and decreases to a larger extent if this dynamic is larger (i.e., larger η_k); X_k* is independent of the initial stock.

Note that solutions for environmental and cultural investments are not correlated with each other. Moreover, the level of X_k* is amended to retain equality between the marginal utility and marginal cost (i.e., $(1 - p_k X_k)/(1 + \rho) = c_k$) by accounting for its average dynamics (i.e., $\pm(T/2)\,\eta_k$). However, if utility depends on the additional amount of X_k (i.e., $X_k - X_k(0)$), then the chosen X_k* would be $X_k + X_k(0)$. Finally, larger T or η_k (i.e., $T\,\eta_k\,p_k > (1 + \rho)\,c_k$) might imply the existence of corner solutions for X_k* (i.e., X_k* = max X_k if $\theta_k\,\eta_k > 0$ and X_k* = min X_k if $\theta_k\,\eta_k < 0$). The right approach for ST is MLCA whenever environmental and cultural dynamics are not negligible.

Many indicators in the literature seem to be suitable for a static assessment of the *crucial* economic and social dimensions of ST (e.g., [69–71]). Torres-Delgado and Saarinen [47] and Blancas et al. [68] discuss indicators at local and national levels, respectively. McLennan et al. [72], Cottrell et al. [73], Paunovic et al. [74], and Perez et al. [5] discuss indicators based on stakeholder assessments. Tanguay et al. [75] describe the most popular indicators. Mikulic et al. [76], Bhuiyan et al. [77], Romero-Padilla et al. [78], Kunasekaran et al. [79], and Mutana and Mukwada [80] discuss various indices based on indicators.

3.3. MCA vs. WLCA for AT

The dynamic AT solutions with WLCA can be described as follows:

$$\begin{aligned} X_{env} = \ & \#\{2c_{env}{}^2 p_{cul} p_{soc} w_{cul} - 2c_{env}{}^3 p_{cul} p_{soc} w_{cul} \\ & + c_{cul}{}^2 p_{cul} p_{env} p_{soc} w_{env} (2X_{env}(T) + 2X_{env}(0) \\ & - \eta_{env} T \theta_{env}) \\ & + c_{env} p_{env} w_{cul} [-2c_{soc}{}^2 p_{cul} - 2c_{soc} p_{cul}(-1 + p_{soc} X_{soc}) \\ & + c_{cul} p_{soc}(2 - 2c_{env} - 2p_{cul} X_{cul}(T) - 2p_{cul} X_{cul}(0) \\ & + \eta_{cul} T p_{cul} \theta_{cul})]\} \end{aligned} \tag{21}$$

where,

$$\# = 1/\left[2p_{\text{cul}}p_{\text{env}}p_{\text{soc}}\left(c_{\text{env}}{}^2w_{\text{cul}} + c_{\text{cul}}{}^2w_{\text{env}}\right)\right]$$

and

$$\begin{aligned} X_{\text{cul}} = \; & \#\{2c_{\text{cul}}{}^2p_{\text{env}}p_{\text{soc}}w_{\text{env}} - 2c_{\text{cul}}{}^3p_{\text{env}}p_{\text{soc}}w_{\text{env}} \\ & + c_{\text{env}}{}^2p_{\text{cul}}p_{\text{env}}p_{\text{soc}}w_{\text{cul}}(2X_{\text{cul}}(T) - \eta_{\text{cul}}T\theta_{\text{cul}}) \\ & + c_{\text{cul}}p_{\text{cul}}w_{\text{env}}[-2c_{\text{soc}}{}^2p_{\text{env}} - 2c_{\text{soc}}p_{\text{env}}(-1 + p_{\text{soc}}X_{\text{soc}}) \\ & + c_{\text{env}}p_{\text{soc}}(2 - 2c_{\text{env}} - 2p_{\text{env}}X_{\text{env}}(T) - 2p_{\text{env}}X_{\text{env}}(0) \\ & + \eta_{\text{env}}Tp_{\text{env}}\theta_{\text{env}})]\} \end{aligned} \tag{22}$$

Next, the dynamic AT monetary solutions can be described as follows based on my assumption that $c_k = w_k$:

$$\begin{aligned} X_{\text{env}} = \; & \S\{-2c_{\text{soc}}{}^2p_{\text{cul}}p_{\text{env}} - 2c_{\text{soc}}p_{\text{cul}}p_{\text{env}}(-1 + p_{\text{soc}}X_{\text{soc}}) \\ & + p_{\text{soc}}[2c_{\text{env}}p_{\text{cul}} - 2c_{\text{env}}{}^2p_{\text{cul}} \\ & + c_{\text{cul}}p_{\text{env}}(2 - 2c_{\text{cul}} \\ & + p_{\text{cul}}(-2X_{\text{cul}}(T) + 2X_{\text{env}}(T) + 2X_{\text{env}}(0) + \eta_{\text{cul}}T\theta_{\text{cul}} \\ & - \eta_{\text{env}}T\theta_{\text{env}}))]\} \end{aligned} \tag{23}$$

where,

$$\S = 1/[(c_{\text{cul}} + c_{\text{env}})p_{\text{cul}}p_{\text{env}}p_{\text{soc}}]$$

and

$$\begin{aligned} X_{\text{cul}} = \; & \S\{-2c_{\text{soc}}{}^2p_{\text{cul}}p_{\text{env}} - 2c_{\text{soc}}p_{\text{cul}}p_{\text{env}}(-1 + p_{\text{soc}}X_{\text{soc}}) \\ & + p_{\text{soc}}[-2c_{\text{env}}{}^2p_{\text{cul}} - 2(-1 + c_{\text{cul}})c_{\text{cul}}p_{\text{env}} + c_{\text{env}}p_{\text{cul}}(2 \\ & + p_{\text{env}}(2X_{\text{cul}}(T) - 2X_{\text{env}}(T) - 2X_{\text{env}}(0) - \eta_{\text{cul}}T\theta_{\text{cul}} \\ & + \eta_{\text{env}}T\theta_{\text{env}}))]\} \end{aligned} \tag{24}$$

In other words, if WLCA is applied, the chosen X_{env} (i.e., X_{env}*) increases with respect to $X_{\text{env}}(0)$. That is, a larger initial amount of environmental resources implies a larger investment in the environment:

$$\partial X_{\text{env}}{}^*/\partial X_{\text{env}}(0) = c_{\text{cul}}{}^2\, w_{\text{env}}/(c_{\text{env}}{}^2\, w_{\text{cul}} + c_{\text{cul}}{}^2\, w_{\text{env}}) \tag{25}$$

X_{env}* increases with respect to $X_{\text{env}}(T)$. That is, a larger long-run amount of environmental resources implies a larger investment in the environment:

$$\partial X_{\text{env}}{}^*/\partial X_{\text{env}}(T) = c_{\text{cul}}{}^2\, w_{\text{env}}/(c_{\text{env}}{}^2\, w_{\text{cul}} + c_{\text{cul}}{}^2\, w_{\text{env}}) \tag{26}$$

X_{env}* does not depend on $X_{\text{cul}}(0)$. That is, a larger initial cultural heritage does not affect investment in the environment ($\partial X_{\text{env}}{}^*/\partial X_{\text{cul}}(0) = 0$), and X_{env}* decreases with respect to X_{soc}. That is, in the context of a fixed budget for a given planning period, reducing social inequality implies a reduction of environmental investments:

$$\partial X_{\text{env}}{}^*/\partial X_{\text{soc}} = -c_{\text{soc}}\, w_{\text{cul}}\, c_{\text{env}}/(c_{\text{env}}{}^2\, w_{\text{cul}} + c_{\text{cul}}{}^2\, w_{\text{env}}) \tag{27}$$

Similar results are obtained if MLCA is applied, where these partial derivatives become $c_{\text{cul}}/(c_{\text{cul}} + c_{\text{env}})$, 0, and $-c_{\text{soc}}/(c_{\text{cul}} + c_{\text{env}})$, respectively. We obtain similar results for the cultural investment decision X_{cul}* if we apply analogous partial derivatives to it.

In particular, AT solutions with WLCA will depend on T as follows:

$$\frac{\partial X_{\text{env}}}{\partial T} = \frac{c_{\text{cul}}c_{\text{env}}\eta_{\text{cul}}w_{\text{cul}}\theta_{\text{cul}} - c_{\text{cul}}{}^2\eta_{\text{env}}w_{\text{env}}\theta_{\text{env}}}{2(c_{\text{env}}{}^2w_{\text{cul}} + c_{\text{cul}}{}^2w_{\text{env}})} \tag{28}$$

and

$$\frac{\partial X_{\text{cul}}}{\partial T} = \frac{c_{\text{cul}} c_{\text{env}} \eta_{\text{env}} w_{\text{env}} \theta_{\text{env}} - {c_{\text{env}}}^2 \eta_{\text{cul}} w_{\text{cul}} \theta_{\text{cul}}}{2({c_{\text{env}}}^2 w_{\text{cul}} + {c_{\text{cul}}}^2 w_{\text{env}})} \tag{29}$$

Next, AT solutions with MLCA will depend on T as follows:

$$\frac{\partial X_{\text{env}}}{\partial T} = \frac{c_{\text{cul}}(\eta_{\text{cul}} \theta_{\text{cul}} - \eta_{\text{env}} \theta_{\text{env}})}{2(c_{\text{env}} + c_{\text{cul}})} \tag{30}$$

and

$$\frac{\partial X_{cul}}{\partial T} = \frac{c_{\text{env}}(\eta_{\text{env}} \theta_{\text{env}} - \eta_{\text{cul}} \theta_{\text{cul}})}{2(c_{\text{env}} + c_{\text{cul}})} \tag{31}$$

Thus, a longer time horizon (T) has the same impact on AT and RT investment solutions. Moreover, the impact of the initial amount of environmental resources on investment decisions is larger in RT than in AT. Finally, social targets have the same impacts on AT and RT investment solutions. The right approach for AT is WLCA whenever environmental and cultural dynamics are not negligible.

Few indicators in the literature seem to be suitable for a dynamic assessment of the *crucial* cultural dimensions of AT [67]. In particular, Blancas et al. [81] suggest indicators for managing the cultural dimension of tourism (e.g., number of cultural properties, practices and expressions inscribed in the UNESCO World Intangible Heritage List or in its Tentative List). Next, Torres-Delgado and Saarinen [47] suggest indicators for assessing the cultural dimension of tourism (e.g., type and amount of training given to tourism employees, employment in producing traditional handicrafts).

4. Comparisons

4.1. Investment Errors with Static Instead of Dynamic Assessments

Comparisons of investment decisions based on static vs. dynamic assessments *can* be performed theoretically. However, I applied three main standardizations. First, for MLCA, I assumed that $\rho = 0$ to allow a comparison of ST with RT and AT. Actually, $\rho = 0$ is the only consistent assumption for an inter-temporal assessment of sustainability for large T. This implies that $c_{\text{eco}} = 1 + \rho = 1$ at equilibrium. Second, I disregarded the relationships between the environmental and cultural flows and the tourist flows by assuming linear relationships between the former flows and the latter flows and by focusing on the dynamics of the former flows. Third, for MLCA, I equalized the relative weights to the marginal utilities (i.e., $1 - p_k = \mathrm{w}_k$). This implies that $\mathrm{c}_k = \mathrm{w}_k$ at equilibrium.

Note that η_{env} is larger if we consider global instead of local sustainability conditions (e.g., intercontinental flights to a locally sustainable atoll). Moreover, in ST, the explicit value of resources comes from their marginal utility, whereas in RT and AT, the implicit value arises from the distance with respect to the current level in RT and with respect to the long-run equilibrium in AT. Finally, comparisons are feasible, since minimising a quadratic distance function amounts to maximising a quadratic utility function if an implicit negative welfare is attached to gaps between the observed level and the desired level, which can be either the current level or the long-run equilibrium level.

Table 3 summarises the errors if a wrong static methodology (i.e., MCA and CBA) instead of a right dynamic methodology (i.e., WLCA and MLCA) is applied.

Table 3. Summary of comparisons between wrong static (i.e., MCA and CBA) versus right dynamic (i.e., WLCA and MLCA) solutions. RT = responsible tourism; ST = sustainable tourism, AT = alternative tourism.

	RT	ST	AT
WLCA-MCA	$X^*_{env}(WLCA) - X^*_{env}(MCA) = \frac{c_{cul}T(c_{env}\theta_{cul}\eta_{cul}w_{cul} - c_{cul}\theta_{env}\eta_{env}w_{env})}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})}$ $X^*_{cul}(WLCA) - X^*_{cul}(MCA) = \frac{c_{env}T(c_{cul}\theta_{env}\eta_{env}w_{env} - c_{env}\theta_{cul}\eta_{cul}w_{cul})}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})}$ $X^*_k(WLCA) - X^*_k(MCA)$ if $c_{cul}\theta_{env}\eta_{env}w_{env} = c_{env}\theta_{cul}\eta_{cul}w_{cul}$		$X^*_{env}(WLCA) - X^*_{env}(MCA) = \frac{c_{cul}T(c_{env}\theta_{cul}\eta_{cul}w_{cul} - c_{cul}\theta_{env}\eta_{env}w_{env})}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})}$ $X^*_{cul}(WLCA) - X^*_{cul}(MCA) = \frac{c_{env}T(c_{cul}\theta_{env}\eta_{env}w_{env} - c_{env}\theta_{cul}\eta_{cul}w_{cul})}{2(c_{env}{}^2 w_{cul} + c_{cul}{}^2 w_{env})}$ $X^*_k(WLCA) - X^*_k(MCA)$ if $c_{cul}\theta_{env}\eta_{env}w_{env} = c_{env}\theta_{cul}\eta_{cul}w_{cul}$
MLCA-CBA		$X^*_k(MLCA) - X^*_k(CBA) = \frac{T\theta_k\eta_k}{2}$	
MLCA-MCA	$X^*_{env}(MLCA) - X^*_{env}(MCA) = \frac{c_{cul}(\theta_{cul}\eta_{cul} - \theta_{env}\eta_{env})T}{2(c_{cul} + c_{env})}$ $X^*_{cul}(MLCA) - X^*_{cul}(MCA) = \frac{c_{env}(\theta_{env}\eta_{env} - \theta_{cul}\eta_{cul})T}{2(c_{cul} + c_{env})}$ $X^*_k(MLCA) - X^*_k(MCA)$ if $\theta_{env}\eta_{env} = \theta_{cul}\eta_{cul}$		$X^*_{env}(MLCA) - X^*_{env}(MCA) = \frac{c_{cul}(\theta_{cul}\eta_{cul} - \theta_{env}\eta_{env})T}{2(c_{cul} + c_{env})}$ $X^*_{cul}(MLCA) - X^*_{cul}(MCA) = \frac{c_{env}(\theta_{env}\eta_{env} - \theta_{cul}\eta_{cul})T}{2(c_{cul} + c_{env})}$ $X^*_k(MLCA) - X^*_k(MCA)$ if $\theta_{env}\eta_{env} = \theta_{cul}\eta_{cul}$

In words, if $w_{env} > w_{cul}$ in RT and $w_{env} < w_{cul}$ in AT, the couples of η_{env} and η_{cul} such that there is excessive environmental investment (i.e., an error level) if MCA is applied instead of WLCA are smaller in RT than in AT. If negative and consonant environmental and cultural dynamics apply, ST shows the smallest error level. In contrast, if MLCA is applied so that the weights equal the marginal costs, there is no difference between RT and AT in terms of error level. Moreover, if MLCA is applied to ST, the errors are not correlated (i.e., cross-dependence on environmental and cultural dynamics), whereas errors of environmental or cultural investments are correlated if WLCA is applied to RT and AT, with errors for AT more correlated than for RT. In contrast, if MLCA is applied, there is no difference between RT and AT in terms of error correlation. Finally, dependence on the couples of tentatively estimated η_{env} and η_{cul} (i.e., error likelihood) if MCA is applied instead of WLCA is smaller in AT than in RT. If negative and consonant environmental and cultural dynamics apply, ST shows the smallest error likelihood. In contrast, if MLCA is applied, there is no difference between RT and AT in terms of error likelihood.

In summary, if negative and consonant environmental and cultural dynamics apply, the overall ranking if a wrong static instead of a right dynamic approach is adopted (e.g., due to a lack of data) is ST > RT > AT if MCA and CBA are applied instead of WLCA and MLCA, respectively; the overall ranking is ST > RT = AT if MCA and CBA are applied instead of MLCA.

Note that errors in RT and AT are never 0 if the dynamics have opposite signs. Moreover, errors do not depend on X_{soc} in RT and AT, although investments depend on X_{soc}, where it is likely that X_{soc} in RT < X_{soc} in AT, with either the same or different distributions. Finally, investments depend on $X_k(0)$ in RT and on $X_k(T)$ in AT, but the errors do not. In summary, unless marginal benefits equal marginal costs, potential interactions between X_{env} and X_{cul} are reflected in the budget constraint, since accounting for the dynamics of external factors could save money that could to be used to improve other beneficial effects or to reduce other detrimental effects.

4.2. Investment Differences with WLCA Instead of MLCA

Comparisons of investment decisions based on WLCA vs. MLCA must be performed empirically. Therefore, I will refer to a case study of the Alta Val Marecchia planning area, located in Northern Italy's Rimini Province, within the Emilia-Romagna region (Figure 3). Note that I did not choose this case study because of its unique characteristics (i.e., I could have chosen many other areas with similar features), but rather because of data availability (i.e., I could have chosen any area with similar data). The study region consists of seven municipalities: Casteldelci, Maiolo, Novafeltria, Pennabilli, San Leo, Sant'Agata, and Talamello.

Figure 3. Location of the case study area.

This area is an interesting case study for two main reasons. First, it is a good example of an area where tourism depends on both natural and cultural resources; tourism firms accounted for 6.9% of the total number of companies in 2011 [82], and 7.7% of these firms were hotels or restaurants. In addition, there is a natural park (i.e., Sasso Simone and Simoncello, 4847 ha), and there are four ancient castles in San Leo, Sant'Agata, Pennabilli, and Casteldelci.

Second, the seven municipalities were added to Rimini Province in 2009, so a large budget (i.e., 12 million euros) was allocated by the Emilia-Romagna Region from 2010 to 2013, with the following distribution: 22% to improve competitiveness, 18% to improve urban quality and sustainable transportation (e.g., private transportation to be replaced by public, trucks to be replaced by trains), 16% to improve the environment, and 44% to improve culture and other local potential [83]. I will use these percentages to calculate costs (i.e., c_{eco}, c_{soc}, c_{env}, and c_{cul}) by disregarding the small amounts of funds (i.e., 10,000 to 20,000 euros each) for specified projects chosen annually by the Emilia-Romagna Region. In contrast, I will refer to the priorities stated by local firms (i.e., 33% for incentives to firms; 51% for infrastructure including roads, hospitals and schools; 6% for the environment, including a dam for hydropower; and 4% for culture; [84]) to calculate the relative weights (i.e., w_{eco}, w_{soc}, w_{env}, and w_{cul}). Note that these percentages do not sum up to 100, since 6% of local firms did not specify a priority.

For tourism *structures*, there are 11 hotels (i.e., one in San Leo, two in Sant'Agata, three in Pennabilli, one in Casteldelci, four in Novafeltria), and 63 alternatives to hotels (40% bed and breakfast (B&Bs), 30% agritourist locations, and 30% camping).

The tourism *flows* are point sources. Indeed, in San Leo, 74,390 castle tickets were sold in 2016. Moreover, the available time series refers to all of the tourist presence in Rimini Province, although agritourist firms are most typical of this area. Finally, single municipality reports record around 50,000 people per year visiting Pennabilli for fairs, street artist festivals, and antique markets; around 150,000 people per year visited Sant'Agata for Christmas, truffle fairs, and novel festivals; and around 50,000 people per year visited San Leo for fairs and music festivals.

Therefore, I will normalize per capita expenditures for economic and social issues by dividing the expenditures by the number of residents (i.e., 17,374 inhabitants in 2016). Moreover, I will normalize per capita expenditures for environmental issues based on stays at hotel alternatives (i.e., 50,079 in 2016). Finally, I will normalize per capita expenditures for cultural issues based on stays in hotels (i.e., 50,840 in 2016; [85]). This leads to Emilia-Romagna Region expenditures of 51 and 41 euro per inhabitant per year for economic and social issues, and of 13 and 35 euros per tourist per year for environmental and cultural issues. Note that stays with agritourist firms reached a peak in 2014 (i.e., 19 521), the year after the planning period of 2010 to 2013.

For the tourism *sector*, the occupancy rate of accommodations was 15% [86]. Thus, I will fix $X_{env}(0) = 50{,}079$ and $X_{cul}(0) = 50{,}840$ based on the observed data in 2016, and set the carrying capacity at twice these values (i.e., Sup $X_{env} = 2 \times 50{,}079$, Sup $X_{cul} = 2 \times 50{,}840$) because doubling the occupancy rate seems to be a plausible target to achieve.

For the area's *economy*, the value added per inhabitant was 24 900 euros, the participation in the tourism industry for residents aged 15 to 64 years is 62.9%, the unemployment rate is 9.1%, and the value added per employee is 58,500 euros. Thus, I estimated X_{soc} in AT by assuming that the objective was to eliminate unemployment (i.e., 994 people) so that 9.1% of the residents would receive employment benefits, and I estimated X_{soc} in RT by assuming that the target was to eliminate unemployment (i.e., 994 people) so that the average value added would increase by 6.1%, under the assumption of a uniform distribution.

Figures 4 and 5 compare the environmental investment decisions (X_{env}) in RT vs. ST, with these values estimated using WLCA and MLCA, respectively. Figures 6 and 7 compare X_{env} in AT vs. ST, with these values estimated by WLCA and MLCA, respectively. Note that the slope of the level curves is -0.37 for all these figures (i.e., differences in investments are equally correlated with the values of cultural dynamics). Supplemental Material II summarizes the relationships among figures, which depend on different assumptions.

Note that I assumed that η measures the dynamics of external factors for a 5-year period, by fixing T at 5 because 25-year planning horizons (i.e., five 5-year periods) seem to be reasonable for the region's natural environmental and cultural heritage. Moreover, I assumed that $p_{soc} = 1$ so that the marginal utility would be positive whenever social investments affected a fraction of or the whole resident population, with the population normalized to 1 (i.e., $X_{soc} \leq 1$). Finally, I normalised $X_{env}(0)$ and $X_{cul}(0)$ to 0.5, Sup X_{env} and Sup X_{cul} to 1, and the long-run $X_{env}(T)$ and $X_{cul}(T)$ to 0.75, with the objective of accounting for the aforementioned potential doubling of the current occupancy rate. This implies that investment differences are in the range [–1, 1].

The *values* of the level curves in Figure 4 suggest that when RT is properly assessed (with WLCA), this tourism typology is *more precautionary* (i.e., resource preservation is more likely) than when ST is correctly assessed (with MLCA) with plausible environmental and cultural dynamics (i.e., $\eta_{env} < 0.5$ and $\eta_{cul} < 0.5$; in words, this represents a decay rate smaller than 50% over the 5 years). Comparing the *distance* between the level curves in Figures 4 and 5 suggests that applying monetary or single-unit measurements (i.e., MLCA) to RT is *riskier* (i.e., differences in investments based on different methodologies are more sensitive to environmental and cultural dynamics).

The *values* of the level curves in Figures 4 and 6 suggest that AT is *more precautionary* than RT at all levels of environmental and cultural dynamics (i.e., at the same environmental and cultural dynamics, a larger investment is chosen; e.g., at $\eta_{env} = \eta_{cul} = 0.1$, $X_{env}* = 0.27$ in RT and $X_{env}* = 0.44$ in AT). Note that both differences in environmental investments (i.e., RT $-$ ST and AT $-$ ST) are $-0.18 + 0.25\ \eta_{cul}$, which is positive for sufficiently large values of η_{cul} (i.e., RT and AT are less risky than ST). Comparing the *distance* between the level curves in Figures 5 and 7 suggests that applying monetary or single-unit measurements (i.e., MLCA) to AT is as *risky* as when they are applied to RT (e.g., at $\eta_{env} = \eta_{cul} = 0.1$, $X_{env}^* = 0.86$ in RT and $X_{env}^* = 0.84$ in AT).

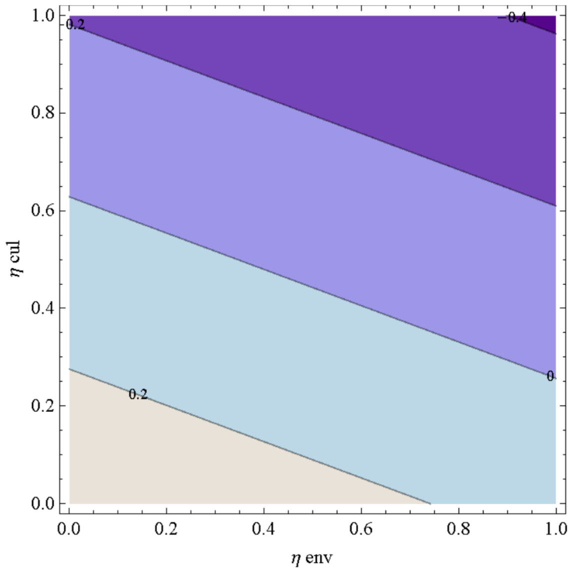

Figure 4. Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if WLCA and MLCA are applied for RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 44% of all possible environmental and cultural dynamics, the distance between the level curves is 0.35.

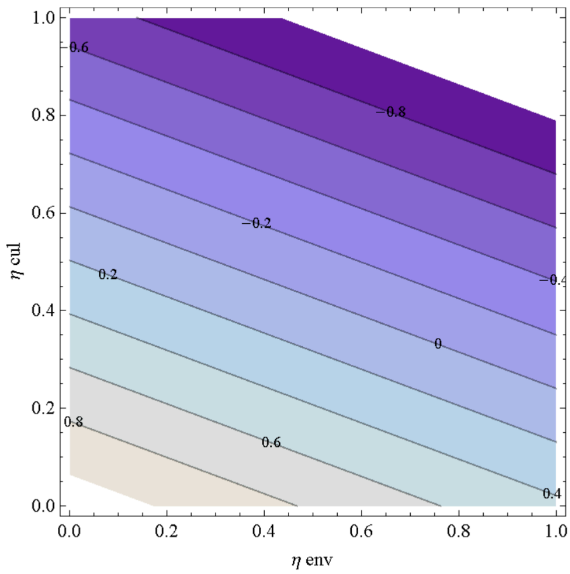

Figure 5. Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if MLCA is applied, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 42% of all possible environmental and cultural dynamics, the distance between the level curves is 0.11.

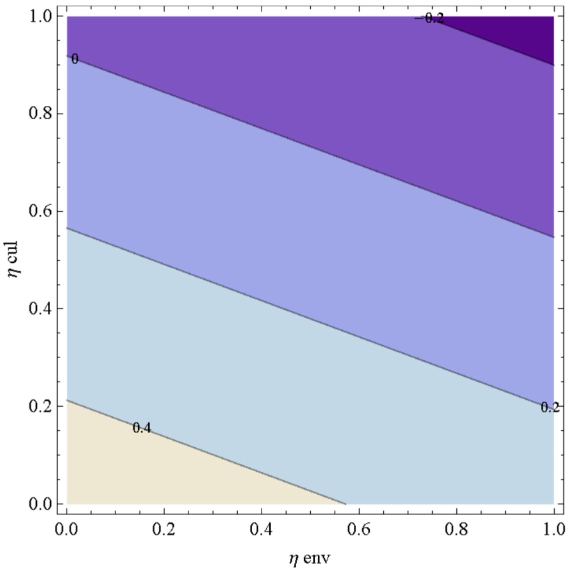

Figure 6. Differences between environmental investments (i.e., AT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if WLCA and MLCA are applied for AT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socat} = 0.09$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for AT are larger than for ST at 73% of all possible environmental and cultural dynamics, the distance between the level curves is 0.35.

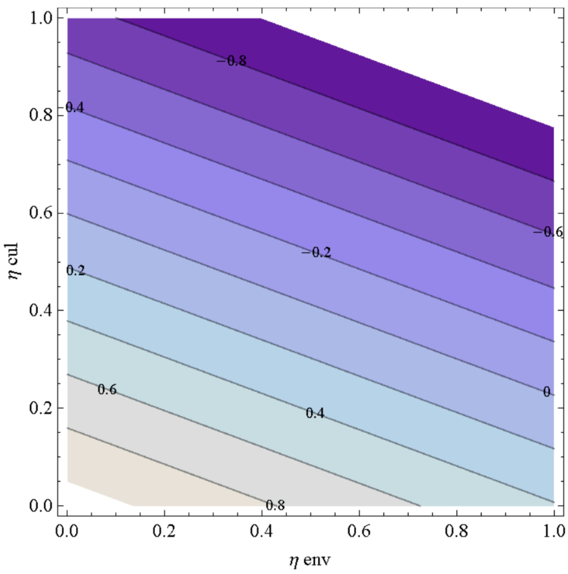

Figure 7. Differences between environmental investments (i.e., AT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if MLCA is applied, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $X_{socat} = 0.09$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for AT are larger than for ST at 41% of all possible environmental and cultural dynamics, the distance between the level curves is 0.11.

Figure 8 illustrates the effects of policies implemented in the form of cost subsidies, where c_{env} is divided by 2 because a subsidisation around 50% has been applied in Italy to support the use of renewable energy. See Figure A1 in Appendix B for RT assessed by MLCA. Comparing the *values* and *slopes* of the level curves in Figures 4 and 8 suggests that subsidizing the environmental costs makes environmental decisions based on RT properly assessed (i.e., using WLCA) *similar* to the decisions based on ST properly assessed (i.e., using MLCA); that is, RT − ST is 0 or close to 0 for a large set of environmental and cultural dynamics, and RT − ST is *uncorrelated* with the value of cultural dynamics (i.e., the level curves are *flatter*) to a larger extent.

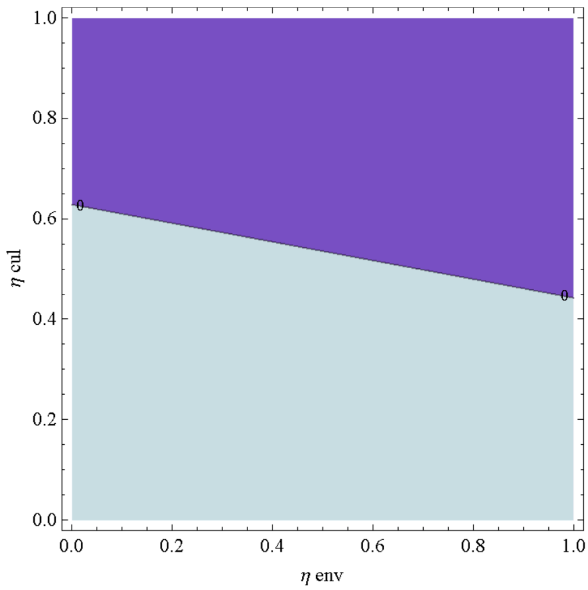

Figure 8. Policies as cost subsidies (i.e., c_{env} divided by 2). Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if WLCA and MLCA are applied for RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.026$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 53% of all possible environmental and cultural dynamics, the slope of the level curves is −0.18, the distance between the level curves is 0.66.

Figure 9 shows the results if policies are expressed as environmental concerns, with w_{env} multiplied by 2 because doubling its current value seems to be a plausible target to achieve for the study area. See Figure A2 in Appendix B for RT assessed by MLCA. Comparing the values of the level curves in Figures 4 and 9 suggests that an information campaign to increase stakeholder concern for the environment would make the environmental decisions based on RT properly assessed (with WLCA) *similar* to the decisions based on ST properly assessed (with MLCA). That is, RT − ST is 0 or close to 0 for a large set of values of environmental and cultural dynamics. Comparing the values and slopes of the level curves in Figures 8 and 9 suggests that subsidizing environmental costs would have effects similar to those of an information campaign for increasing stakeholder concerns for the environment, although at a smaller set of values for cultural dynamics.

Note that using relative budgets as relative weights leads to the same investment decisions obtained by applying monetary assessments (i.e., investment decisions depend on the difference between politician and stakeholder priorities). Moreover, standardisations per inhabitant and per tourist (i.e., 51, 41, 13, and 35 euros per person for economic, social, environmental, and cultural issues, respectively) did not affect the relative costs. Finally, differences in investment decisions turn out to depend on the relative importance attached to the four pillars (economic, social, environmental, and cultural features) for each given absolute level of funds (i.e., differences in investment decisions are independent of the budget constraints).

Appendix C summarises the results of numerical simulations performed for all alternative pairs of consonant or dissonant dynamics. In summary, if RT, AT, and ST are properly assessed, then in terms of investment decisions, AT is more precautionary than RT (which is consistent with the goal of maximizing continuity), although this also depends on $X(T)$ and X_{soc} in AT, which are both larger than they are in RT. In addition, RT is more precautionary than ST (independently of all possible pairs of consonant or dissonant dynamics, although to a different extent for each dynamic). In other words, to preserve natural resources and cultural heritage, the goals and weights are crucial. For the tourism policies, RT is similar to ST, which is in turn similar to AT. In other words, in choosing between policies expressed as environmental concerns and policies expressed as cost subsidies, the assessment methodology appears to be irrelevant. Note that here, I estimated the differences in investment decisions based on all feasible combinations of environmental and cultural dynamics. However, in order to determine the investment levels, reliable estimates of η_{env} and η_{cul} are required. Thus, ST is safer (i.e., the possible investment errors are smaller), since investment decisions in one dimension (e.g., environmental) are uncorrelated with investment decisions in the other dimensions.

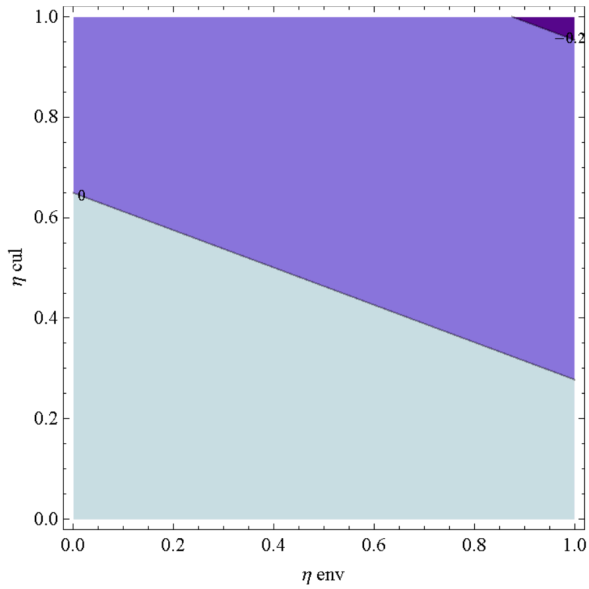

Figure 9. Policies expressed as environmental concerns (i.e., w_{env} multiplied by 2). Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if WLCA and MLCA are applied for RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.12$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 46% of all possible environmental and cultural dynamics, the slope of the level curves is −0.37, the distance between the level curves is 0.67.

5. Discussion

Section 4 highlighted which assessment methodology should be adopted for which tourism typology or goal: Section 4.1 discussed investment errors if a static instead of a dynamic approach is adopted, for a given tourism typology, whereas Section 4.2 discussed investment characteristics if alternative tourism goals are pursued, for the same dynamic approach. Table 4 summarizes papers that have applied alternative assessment methodologies to RT, ST, and AT as tourism typologies. I allocated papers to MLCA if the estimates were combined in a single unit, either monetary or not; to RT if cultural issues were not considered; to ST if the willingness to pay or the analytic hierarchy process was applied to stakeholder perceptions or estimates; and to AT if cultural issues were considered. The papers based on relative weights applied to percentage changes of incommensurable indicators are allocated to MCA, whereas papers based on monetary assessments of all features are allocated to CBA.

Note that I disregarded sustainability as perceived by tourists [17,22,87] or residents [88]. Moreover, macro-impacts such as the effect on the balance of payments and public facilities are not included [40]. Finally, I disregarded the use of innovation to promote sustainability [89].

Table 4. Summary of papers that have applied alternative assessment methodologies to responsible, sustainable, and alternative tourism typologies. CF = carbon footprint in $MtCO_2$/year; EF = ecological footprint in ha; EI = environmental indicators; GHG, greenhouse gases.

	Responsible Tourism	**Sustainable Tourism**	**Alternative Tourism**
MCA	Michailidou et al. [90] Transport and accommodation to CF and EI Latinopoulos and Vagiona [91] economic and ecological indicators with stakeholder involvement		Bucurescu [92] Matrix method for cultural heritage and economic features Iliopoulou-Georgudaki et al. [24] 18 indicators combined to produce 4 thresholds
CBA		Mutana and Mukwada [80] See below for other papers based on stakeholder perceptions	
WLCA	Uche et al. [93] Social features, environmental pollution, environmental resources in the context of water uses in agriculture and tourism Kuo et al. [94] Energy and GHG in tourism (kJ and kg per tourist)		
MLCA	Castellani and Sala [95] Energy and fuel to EF See below for other papers on CF	Foolmaun and Ramjeawon [96] Economic, social, and environmental impacts of plastic combined with the analytic hierarchy process	

Static papers on stakeholder perceptions about tourism impacts: [5,6,46,49–51,61,62,73,74,77,97]. Dynamic papers on environmental impacts based on CF: [98], wastes in petroleum and tourism (kg/day); [99], GHG in transport to CF; [100], energy, water, waste in transport and accommodation to CF; [101], GHG in input and output investment to CF; [102], GHG in a holiday farm to CF; [103], direct and indirect area GHG to CF; [104], direct and indirect GHG in area to CF; [105], fuel in local transport to CF; [106], kWh and MJ in hotels to CF.

Several of the papers in Table 4 have discussed stakeholder perceptions of tourism impacts, but they were developed within a static framework. Several innovative methodologies have been suggested to develop synthetic indicators. For example, Kunasekaran et al. [79] considered many environmental and cultural indicators (i.e., 11 dimensions) to measure three constructs (i.e., community resources, community development, and sustainable tourism), but these were based on stakeholder perceptions. Several of the papers in Table 4 discussed environmental impacts, but they were based on single indicators such as the carbon footprint or ecological footprint.

In summary, two of the papers in Table 4 discussed AT with respect to cultural issues, but they were static. There is a single paper in Table 4 with a dynamic ST, but it focused only on environmental pollution. Two of the papers in Table 4 relied on MCA for RT for at least two environmental issues (water and waste), but they were also static. Two papers in Table 4 relied on WLCA for RT by focusing on two stocks (greenhouse gases and groundwater) or two flows (i.e., pollution and energy), but they neglected cultural issues. In other words, cultural issues were overlooked by all these tourism characterisations due to a lack of cultural indicators. Thus, additional papers on AT that incorporate cultural issues are urgently needed.

From the discussion of investment errors in Section 4.1 and investment characteristics in Section 4.2., I obtained some insights on choices between assessment methodologies in case a static approach must be implemented, and between tourism goals in case a dynamic approach is implemented. In particular, the main management and policy recommendations can be summarized as follows. If choices are driven by the perceived goals, RT coupled with WLCA should be chosen if minimum impacts are pursued, with concerns as policies: there is correlation between errors and investments, if a static instead of a dynamic approach is adopted, and it is less precautionary and risky than ST; RT is more risky if MLCA is applied. ST coupled with MLCA should be chosen if maximum welfare is pursued, with subsidies as policies: there is no correlation between errors and investments. AT coupled with WLCA should be chosen if maximum continuity is pursued, with concerns as policies: there is correlation between errors and investments, it is more precautionary but less risky than ST; AT is more risky if MLCA is applied. If choices are driven by the available static data, CBA applied to ST should be preferred to MCA applied to RT and AT, although AT is more precautionary than RT. If choices are driven by the investment characteristics, AT is more precautionary than ST, which is more precautionary than RT; ST is uncorrelated with dynamic variables, whereas RT and AT show similar correlations; RT is as risky as AT, and RT and AT are less risky than ST.

Comparing these insights about optimal choices with the distribution of papers among assessment methodologies and tourism typologies presented in Table 4 suggests that the many papers using CBA are satisfactory, due to the smaller investment errors than MCA in case of lack of dynamic data; in contrast, the many papers using MLCA are unsatisfactory, because of the larger investment risk than WLCA in case of monetary or single-unit measurements.

The main limitation of the present study is that conflicts between stakeholders are assumed to be solved before taking investment decisions: in future research, potential conflicts between tourists and their hosts could be depicted by evolutionary games (e.g., [107]), the tragedy of the commons could be represented by game theoretic models (e.g., [108]) or systemic approaches (e.g., [109]), and the potential conflicts between hosts could be depicted by Nash bargaining solutions (e.g., [110]).

Note that decision-making methodologies are necessarily linked to tourism goals (e.g., welfare maximisation requires CBA and MLCA in static and dynamic contexts, respectively), but the methodologies are independent of tourism types. Moreover, in theory, tourism goals could be meaningfully combined as couples (i.e., impact minimisation plus welfare maximisation; continuity maximisation plus welfare maximisation), although my reference to only four pillars (i.e., economic, social, environmental, and cultural) to allow reliable estimation of the relative weights implies, in practice, that few feasible solutions can be identified. That is, many feasible solutions are based on extreme parameter values such as a static context (with $T = 0$), no dynamics for cultural heritage (with $\theta_{cul} = 0$), or no costs for cultural investments (with $c_{cul} = 0$). Finally, this methodological study aims to meaningfully match tourism typologies and goals with planning and managing support tools; however, it also produces an empirical value. This values does not rely on the presented case study, where a sufficient dataset is available, but rather on a realistic analysis of all combinations of environmental and cultural dynamics, which could be estimated in other areas where similar data were available.

6. Conclusions

In this paper, I started by defining key terms and goals for the main tourism typologies (Section 2), and then identified assessment methodologies and indicators that could be applied to support the planning and management of tourism, both theoretically (Section 3) and empirically (Section 4). This improved theoretically the tourism classifications. However, my literature review empirically suggested that these methodological rules are rarely implemented.

In particular, I achieved all objectives originally stated (Section 1): WLCA should be implemented to assess RT, MLCA to assess ST, WLCA to assess AT. Dynamic indicators are required for the environmental dimensions of RT, static indicators are acceptable for ST, dynamic indicators are required for the cultural dimensions of AT. If a wrong static instead of a right dynamic approach is adopted, investment errors are larger in AT than in RT, which are larger than in ST; investment errors are not correlated in ST, whereas they are correlated in RT and AT, with correlation in AT larger than correlation in RT; investment errors are more likely in RT than in AT, which are more likely than in ST; if a monetary or single-unit instead of a weighted approach is adopted, investment errors are similar in size, correlation and likelihood in RT and AT. If tourism typologies are properly assessed, investments in AT are more precautionary than in ST, which are more precautionary than in RT; investments in RT and AT are equally correlated, but more correlated than in ST; investments in RT and AT are equally risky, but less risky than in ST. If a monetary or single-unit instead of a weighted approach is adopted, investments in ST are more precautionary than in RT, which are more precautionary than in AT; investments in RT and AT are equally correlated, but more correlated than in ST; investments in RT and AT are equally risky, but more risky than in ST. Effective environmental policies based on subsidies make RT significantly more precautionary, less correlated and less risky than ST; effective environmental policies based on campaigns make RT slightly more precautionary and less risky than ST, although similarly correlated.

In summary, if a wrong static instead of a right dynamic approach is adopted, ST reduces the size, correlation and likelihood of errors; if a dynamic approach is adopted, AT is the best in terms of precaution, ST is the best in terms of correlation, and RT is the best in terms of risk of investments.

Three main *practical* suggestions arise from the insights provided by this study, starting from data availability and contextual characteristics. First, one should coherently apply the available indicators by correctly naming the analysis based on the selected analytical method. For example, if you are confident that you are facing a marginal model (i.e., without interactions between variables) and that you can properly estimate the willingness to pay, you can apply CBA (i.e., it is the safest methodology, with smaller and uncorrelated errors) and you can then say that your analysis is based on ST. Indeed, MLCA should be better than CBA for ST, but CBA is inconsistent with RT and AT. In contrast, if you have no data on dynamic or cultural variables, apply MCA (i.e., it is the safest methodology, with relatively small errors), and you can then say that your analysis is based on RT, since it is not possible to speak of AT if either cultural issues are neglected or a static analysis is performed. Indeed, WLCA should be better than MCA for AT, but MCA is inconsistent with ST and is dangerous for RT.

Second, one should involve stakeholders in estimating weights (e.g., w_{env} vs. w_{cul}), but not in measuring the indicators (e.g., c_{env} vs. c_{cul}). Indeed, an efficient use of natural or cultural resources, based on stakeholder evaluations, does not imply the preservation of environmental and cultural stock. For instance, in the presented case study, relative weights of environmental and cultural issues by politicians were at 16 and 44%, respectively, whereas the relative weights proposed by stakeholders were 6 and 5%.

Third, one should account for the signs (positive or negative) of the environmental and cultural dynamics by specifying whether they are consonant (have the same sign) or dissonant (have different signs), since investments are likely to be inadequate or excessive in specific contexts with alternative methodologies. For example, the application of MCA to RT is acceptable, but it is likely to produce excessive investment compared with ST in the case of consonant and small dynamics. Similarly, the application of WLCA to AT is necessary, but it is likely to produce insufficient investment compared with ST in the case of dissonant dynamics, with a negative and large environmental dynamic and a small positive cultural dynamic.

Three main developments seem to be required in future research. First, one should introduce sectoral interdependencies. Hadjikakou et al. [111] discuss this in the context of an input–output analysis. Second, one should introduce the effects of spatial interactions. Aminu et al. [112] discuss this in the context of a spatial decision support system based on geographic information system (GIS)-based land-use suitability indices. Third, one should introduce the possibility of interactions among environmental and cultural variables. Nair and Choudhary [56] discuss this in the context of an econometric analysis of marginal interactions.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/11/4/1038/s1, Table S1: The main simplifying assumptions, Table S2: title, Video S1: Relationships between figures based on changes in the assumptions. Figures A3–A5 in the Appendix C were obtained from Figure 4 by replacing negative environmental and cultural dynamics (i.e., $\theta_{env} = \theta_{cul} = -1$) with all possible alternatives (i.e., $\theta_{env} = 1$ and $\theta_{cul} = -1$; $\theta_{env} = -1$ and $\theta_{cul} = 1$; $\theta_{env} = \theta_{cul} = 1$).

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Appendix A

By focusing on positive dynamics (i.e., $\theta_k > 0$) as an example, since similar conditions could be obtained in alternative scenarios, both impact minimisation and welfare maximisation can be achieved if the following conditions hold:

$$p_{soc} = \frac{2c_{soc}(1 - c_{soc})}{2c_{soc}X_{socrt} - c_{env}\eta_{env}T\theta_{env} - c_{cul}\eta_{cul}T\theta_{cul}}, p_{env} = \frac{1}{X_{env}(0)}, p_{cul} = \frac{1}{X_{cul}(0)}$$

and

$$c_{env} = \frac{w_{env}X_{env}(0)}{w_{cul}X_{cul}(0) - w_{env}X_{env}(0)} > 0$$

In other words, this means that the optimality conditions (i.e., first-order conditions for welfare maximisation) must be met at the current stock levels for both environmental and cultural features.

By focusing on positive dynamics (i.e., $\theta_k > 0$) as an example, since similar conditions could be obtained in alternative scenarios, both continuity maximisation and welfare maximisation can be achieved if the following conditions hold:

$$p_{soc} = \frac{2c_{soc}(1 - c_{soc})}{2c_{soc}X_{socrt} - c_{env}\eta_{env}T\theta_{env} - c_{cul}\eta_{cul}T\theta_{cul}}, p_{env} = \frac{1}{X_{env}(T)}, p_{cul} = \frac{1}{X_{cul}(T)}$$

and

$$c_{env} = \frac{w_{env}X_{env}(0)}{w_{cul}X_{cul}(T) - w_{env}X_{env}(T)} > 0$$

In words, this means that the optimality conditions (i.e., first-order conditions for welfare maximisation) must be met at the long-run equilibrium stock levels for both environmental and cultural features.

Appendix B

Comparing the values, distance, and slopes of the level curves in Figures 5 and A1 suggests that although subsidizing environmental costs if RT is assessed with MLCA increases the precautionary aspect, it does not reduce riskiness, and it decreases dependence on environmental and cultural dynamics.

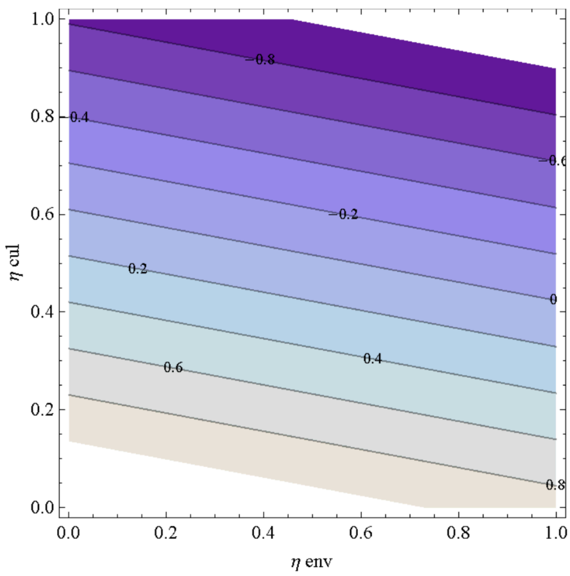

Figure A1. Policies as cost subsidies (i.e., c_{env} divided by 2). Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if MLCA is applied, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.026$, $c_{cul} = 0.035$, $Z = 4000$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 51% of all possible environmental and cultural dynamics (i.e., precaution), the slope of the level curves is −0.18, the distance between the level curves is 0.09.

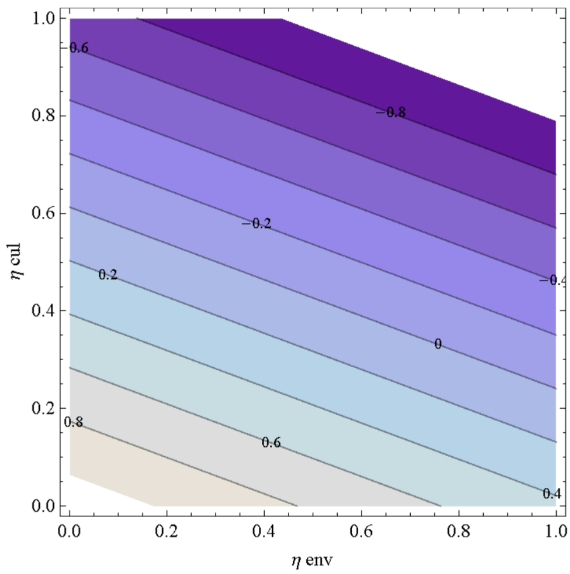

Figure A2. Policies expressed as environmental concerns (i.e., w_{env} multiplied by 2). Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and cultural variables (i.e., $\theta_{env} = \theta_{cul} = -1$) if MLCA is applied, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 42% of all possible environmental and cultural dynamics, the slope of the level curves is −0.18, the distance between the level curves is 0.09.

Comparing the values of the level curves in Figures 5 and A2 suggests that an information campaign to increase stakeholder concerns for the environment if RT is assessed with MLCA would increase the precautionary aspect, would not reduce riskiness, and would decrease dependence on environmental and cultural dynamics. Comparing the values of the level curves in Figures A1 and A2 suggests that subsidizing environmental costs is more precautionary than a campaign to increase concern about the environment.

Appendix C

In this section, I present the results of numerical simulations for alternative values of θ_{env} and θ_{cul}.

Comparing the values and slopes of the level curves in Figures 4 and A3 shows that if the environmental dynamic is positive while the cultural dynamic is negative, instead of both having negative dynamics, RT properly assessed (with WLCA) will be more precautionary than ST for large environmental dynamics, and equally uncorrelated with cultural dynamics, although with opposite signs. Supplemental Material II summarizes the relationships between figures.

Comparing the values and slopes of the level curves in Figures 4 and A4 shows that if the environmental dynamic is negative while the cultural dynamic is positive, instead of both having negative dynamics, then RT properly assessed (with WLCA) is even more precautionary than ST for all environmental dynamics, and equally uncorrelated with cultural dynamics, although with opposite signs.

Comparing the values and slopes of the level curves in Figures 4 and A5 if both dynamics are positive, instead of both having negative dynamics, suggests that RT properly assessed (with WLCA) is even more precautionary than ST for all environmental dynamics, and equally uncorrelated with cultural dynamics, although with opposite signs.

In summary, X^{*}_{env} in RT is more precautionary than it is in ST according to the following rankings: both positive dynamics > negative environmental and positive cultural dynamics > positive environmental and negative cultural dynamics > both negative dynamics.

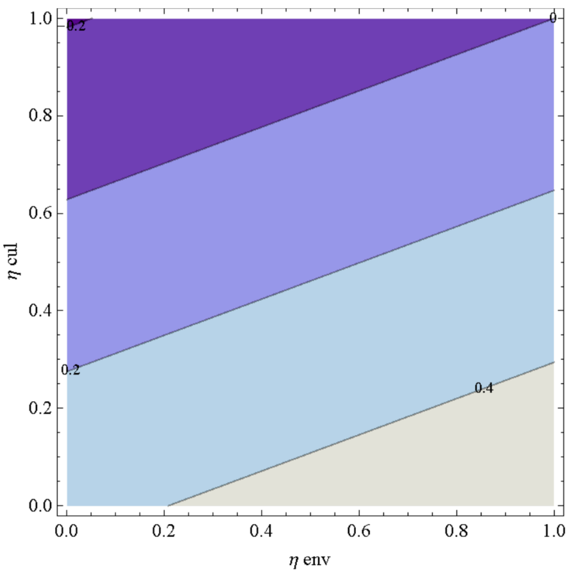

Figure A3. Differences between environmental investments (i.e., RT − ST) in the case of increasing environmental and decreasing cultural variables (i.e., $\theta_{env} = 1$ and $\theta_{cul} = -1$) if WLCA and MLCA are applied to RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 81% of all possible environmental and cultural dynamics, the slope of the level curves is 0.37, the distance between the level curves is 0.35.

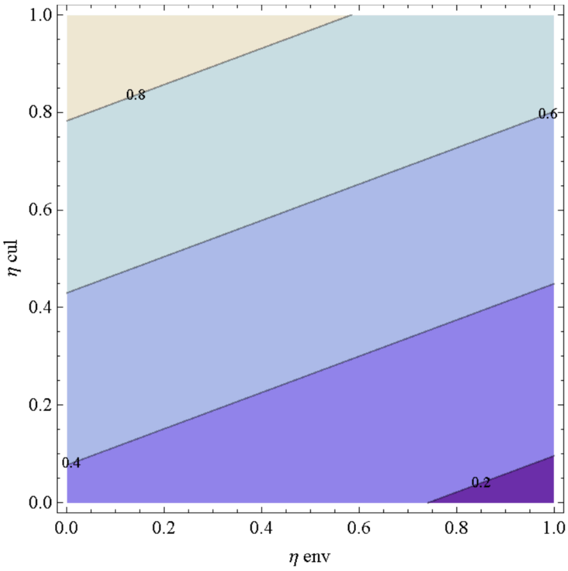

Figure A4. Differences between environmental investments (i.e., RT − ST) in the case of decreasing environmental and increasing cultural variables (i.e., $\theta_{env} = -1$ and $\theta_{cul} = 1$) if WLCA and MLCA are applied to RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, and $X_{cul}(T) = 0.75$. Investments for RT are larger than for ST at 100% of all possible environmental and cultural dynamics, the slope of the level curves is 0.37, the distance between the level curves is 0.35.

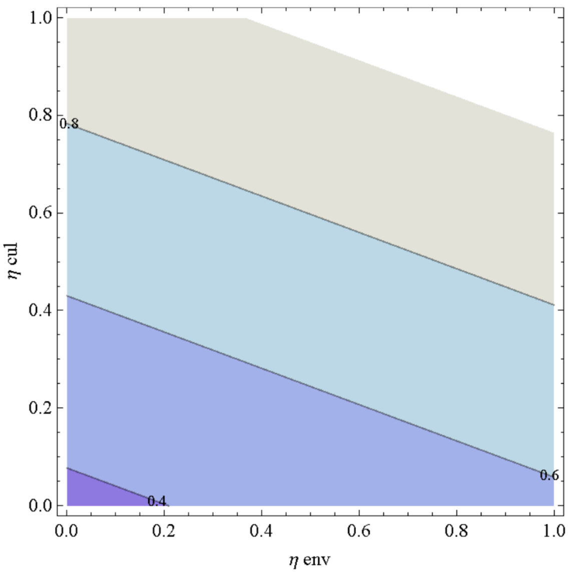

Figure A5. Differences between environmental investments (i.e., RT − ST) in the case of increasing environmental and decreasing cultural variables (i.e., $\theta_{env} = \theta_{cul} = 1$) if WLCA and MLCA are applied to RT and ST, respectively, with $p_{eco} = 0$, $p_{soc} = 1$, $p_{env} = 1$, $p_{cul} = 1$, $c_{eco} = 0.051$, $c_{soc} = 0.041$, $c_{env} = 0.013$, $c_{cul} = 0.035$, $Z = 4000$, $w_{eco} = 0.33$, $w_{soc} = 0.51$, $w_{env} = 0.06$, $w_{cul} = 0.04$, $X_{socrt} = 0.06$, $X_{env}(0) = 0.5$, $X_{cul}(0) = 0.5$, $X_{env}(T) = 0.75$, $X_{cul}(T) = 0.75$. Investments for rT are larger than for ST at 100% of all possible environmental and cultural dynamics, the slope of the level curves is −0.37, the distance between the level curves is 0.35.

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