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**Title**

Modeling Resilient Ethics

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## **Modeling Resilient Ethics**

### **Abstract**

Moral priorities may change in extreme situations such as disasters, and stakeholders may find it difficult to select the most acceptable actions. We propose a social-ecological model of resilient ethics that can provide the best acceptable guideline for action under the most appropriate ethical principle in a given context during the course of disaster management, in the domain of community disaster resilience. The conceptual model is deployed in the form of a non-numerical matrix with the time dimension of the context in the rows and the spatial dimension in the columns. The elements of the matrix are associations of ethical principles and acceptable actions, and each element corresponds to a particular context. The multiplicity of contexts and, thus, of ethical principles and guidelines for action, gives the model its dynamics and makes ethics highly adaptive, in a way, resilient. The proposed interdisciplinary model is a contribution to the 11th Sustainable Development Goal related to sustainable cities and communities. Although presented here in the field of community disaster resilience, the matrix form makes it easily adaptable to other fields, such as robotics, which is a field for which the issue of ethics is essential.

### **Key words**

moral priority; ethical action; social-ecological model; non-numerical matrix; community disaster resilience

## **Modeling Resilient Ethics**

The Covid-19 pandemic raised the need to change the attitudes and behaviors of the people in order to control and reduce the pandemic-related risks, and this has been promoted at the governance level. We generalize this to the management of any disasters, focusing on the ethical facet of actions, behaviors and practices.

Starting from the premise that human conduct is governed by ethical rules, the question is how to consider the dynamics of ethics that translate into actions, behaviors and practices, when facing the need to adapt to new constraints arising in disaster management, and this in all spheres of human activities. In other words, the focus is on how ethics can be made resilient to guide conduct in evolving dynamic situations related to disaster events.

The aim of this study is to reduce the level of abstraction of the idea of resilient ethics that has been introduced at the beginning of the Covid-19 pandemic (Rajaonah & Zio, 2020). To this end, a model of resilient ethics in the context of disaster management is proposed. It would theoretically allow decision makers to decide on ethical actions according to the moral priorities that emerge in particular contexts during the course of the disaster.

Ethics, when synonymous of the morality that underpins human behavior, is primarily a matter of philosophy (for example, see the book *A companion of ethics*, Singer, 1993). Modeling philosophical entities is rather challenging because they are completely abstract, so morality can only be hypothesized and inferred.

This notwithstanding, moral rules do exist and our proposed model is based on the expected relationships between such rules and the consequent expected behavior. Hence, the model of resilient ethics here presented is intended for adaptive decision-making by the stakeholders who have to decide on necessary and/or useful actions during disaster management.

The paper is organized as follows. The next section describes the theoretical framework underpinning the model in three parts, namely, the worldwide program of disaster reduction, the indissociable concept of community resilience to disaster, and ethics. Section 2 presents the proposed social-ecological model of resilient ethics, first described non-formally in terms of content, then with formal terminology, and finally by a non-numerical matrix that represents the dynamics of ethics. The last section highlights on the contributions and limitations of our work.

## **1 Theoretical Background**

The theoretical background of the modeling work proposed is threefold: institutional context of natural disaster reduction, community disaster resilience, ethics.

### **1.1 Natural Disaster Reduction**

The consideration of natural disaster reduction at the high level of international governance, particularly at the level of the United Nations (UN), has a somewhat long history<sup>1</sup>.

- 1971: The United Nations Disaster Relief Office (UNDRO) was established to, among other things, promote the study, prevention control and prediction of natural disasters, advise governments and improve national disaster warning systems.
- 1987: The 1990s were declared the International Decade for Natural Disaster Reduction, with an emphasis on international cooperation.
- 1994: The First World Conference on Natural Disaster Reduction, held in Japan under the auspices of the United Nations, adopted the Yokohama Strategy for a Safer World; it consisted of guidelines for the prevention, preparedness and mitigation of natural disasters to reduce human and economic losses from disasters; strengthening the resilience of communities to cope with natural disasters was

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<sup>1</sup> The history of disaster risk reduction: (accessed on 25 Jan. 2024)

among the guidelines; finally, it was explicitly stated that the guidelines should be considered alongside environmental protection and sustainable development.

- 2005: The second conference, held in Kobe, Japan, adopted the Hyogo Framework for Action 2005–2015, dedicated to the resilience of nations and communities to disasters caused by natural hazards and related environmental and technological hazards and risks. The challenge was to significantly reduce disaster losses in lives and in the social, economic, and environmental assets of communities and countries. The framework promoted: a culture of safety and resilience at all levels (i.e., citizens, disaster professionals and managers, scientists, etc.) through the exchange of information and best practices, partnerships at local, national, regional and international levels, education and training; the reduction of the underlying risk factors (environmental, socio-economic); and the strengthening of disaster preparedness for effective response at all levels (UN, 2005).
- 2015: The third conference in Sendai, Miyagi, Japan adopted the Sendai Framework for Disaster Risk Reduction 2015–2030, which led to the prevention of the emergence of new disaster risks<sup>2</sup>, and the reduction of existing risks by reducing exposure<sup>3</sup> and vulnerability<sup>4</sup> (UN, 2015a). This shift towards risk takes us back to 1994, when it was emphasized that disaster reduction should be considered alongside environmental protection and sustainable development. Indeed, in addition to most of the measures already defined in the Hyogo Framework, the Sendai Framework includes guidelines that ultimately refer to the need to pursue the UN Sustainable Development Goals (SDGs)<sup>5</sup> – such as addressing poverty (SDG 1), inequality (SDG 10), unplanned and rapid

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<sup>2</sup> According to the UNDRR glossary, disaster risk is the “potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity” (<https://www.undrr.org/terminology/disaster-risk>, accessed on 29 Jan. 2024)

<sup>3</sup> Exposure is the “situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas” (<https://www.undrr.org/terminology/exposure>, acc. *ibid.*)

<sup>4</sup> Vulnerability is the “conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards” (<https://www.undrr.org/terminology/vulnerability>, acc. *ibid.*)

<sup>5</sup> The United Nations’ 17 Sustainable Development Goals: <https://sdgs.un.org/goals>

urbanization (SDG 11), and climate change (SDG 13)—in order to limit disaster risks (see UN, 2015b).

- 2023: The UN Global Assessment Report on Disaster Risk Reduction highlighted the central role of resilience in achieving both the SDGs and disaster risk reduction, at least at three levels: resilience of people, resilience of the planet and economic resilience (UNDRR, 2023).

In summary, Disaster Reduction is a very high-level strategy, divided into a series of guidelines addressed to governments and to local, national and international stakeholders who have a say in disaster management. In practice, everyone is affected by this high-level strategy, just like everyone is affected by the achievement of the Sustainable Development Goals.

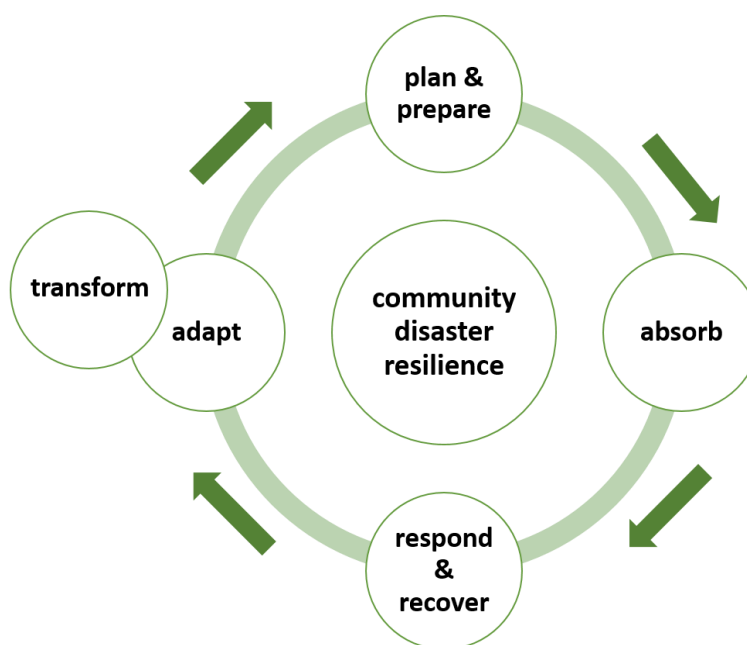
## 1.2 Community Disaster Resilience

One common denominator between Disaster Reduction and SDGs is resilience (UNDRR, 2023). Linkov and Trump (2019) note that in the literature, resilience is considered either as an ability or as a dynamic process that spans a continuum from one phase to another. The phases, according to the 2012 US National Academy of Sciences on the national imperative to increase disaster resilience, are: planning and preparing for; absorbing; responding to and recovering from disasters; and adapting to new conditions (National Research Council—NRC, 2012). Note that these phases (or stages or steps) have since then been widely adopted in many domains (e.g., critical infrastructures, see Zio, 2016; vaccine supply chain, see Trump et al. 2022; smart cities, see Bellini et al., 2022).

We adopt the definition of resilience that expresses the inherent dynamics of the process, but we enrich it with the perspective that, given the interconnectedness of human systems (people and economic, political, cultural and technological systems) and natural systems, people and nature are seen as intertwined in the same dynamic social-ecological system (e.g., Folke, 2006; Reyers et al., 2018), and that such a system should therefore be the unit of interest for research on resilience (e.g., Biggs et al., 2022). Finally, we also consider the transformation stage that is necessary when adaptation is not

sufficient and new relationships among and between people and nature need to be established (e.g., Reyers et al., 2018, Walker et al. 2004). Hence, the following definition of community disaster resilience, based on Folk (2006, 2016) and Folk et al. (2010) is adopted.

The resilience of a community to disasters is the capacity of that social-ecological system to absorb disturbances from adverse events (such as droughts, floods, earthquakes or wars), to adapt, even to transform when the ecological, economic or social structures make the system untenable, but to continue to develop<sup>5</sup> and maintain the same identity despite change. Figure 1 illustrates the dynamics of resilience over time in confronting with disaster occurrences, according to the stages of NRC (2012) and the additional stage of transformation.



*Figure 1 The stages of resilience in the face of disasters*

The concept of identity is based on the assumption that, contrary to the engineering perspective (see Holling, 1996), a social-ecological system has potentially more than one state of equilibrium and more than one way to achieve stability while remaining the same in terms of identity: resilience is the capacity that enables the system to maintain its identity despite transformation (see Bousquet et al., 2021; Delettre, 2021).



For example, Rotarangi explained the resilience of the Māori Ngāti Tūwharetoa community in the face of disturbances (such as loss of sovereignty and autonomy over land and resource management, poverty and war) due to changes in ownership and transformation of their ancestral land around Lake Taupō<sup>6</sup> since the 19th century: they fought to put their values above all else in confrontations and negotiations with the British Crown, which has resulted in the persistence of their cultural identity until now (Rotarangi, 2011; Rotarangi & Stephenson, 2014).

### 1.3 Ethics

In fact, the Māori concept of *tikanga* is at the heart of the resilience of the social-ecological system formed by Ngāti Tūwharetoa and their land around Lake Taupō: it is an excellent introduction to ethics in the context of interest in this work. Indeed, *tikanga* encompasses what guides or even formalizes behavior, social interactions and interactions with the environment (including resource management) in Māori culture; that is, according to The Encyclopedia of New Zealand<sup>7</sup>, it concerns practice, convention and protocol. It can be considered as a kind of Māori ethics specifying guidelines of acceptable behavior and the correct way of doing something, the root of *tikanga* being *tika*, which has to do with the concepts of correctness, rightness and justice (see Mead, 2016).

The need to establish enduring rules to arbitrate priorities between motives for behavior within human groups may have been the basis of some kind of moral sense in the very distant past of humanity (Midgley, 1993). In the case of Maori culture, some principles that underlie *tikanga* go back less far in time; for example, *tika* is linguistically shared with other Polynesian people. In even more recent past, individuals and communities were governed by precepts (e.g., the Five Precepts of Buddhism, e.g., Goodman & Schultz, 2024) or by rituals such as those described in Confucius's Analects (e.g., Csikszentmihalyi, 2024). And today, many people around the world explicitly or implicitly follow commands and commandments of one or another of the three Abrahamic faiths (e.g., Abubakar, 2021).

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<sup>6</sup> In New Zealand

<sup>7</sup> <https://teara.govt.nz/en/copyright>, accessed on 11 July 2024

Not to mention the concern for the environment, which is (or should be) the responsibility of each and everyone of us, encouraging behavior that cares for future generations and nature (e.g., Jonas, 1984).

All these kinds of moral issues, which refer to desirable, recommended, acceptable or forbidden behavior, are related to what is often called ethics<sup>8</sup> in Western countries. More precisely, ethics is either a matter of philosophy, as the study of moral norms and morality (e.g., Ricoeur, 2000), or a matter of society, as about the appropriateness of rules, duties, obligations, prohibitions or priorities in the social system of a given community for a given context, time and place. We think that the mentioned *tikanga Māori* (Mead, 2016) is the case of ethics as a matter of society. The reason why *tikanga* still permeates Maori culture despite regional variations is because it “adapts and accommodates to the rhythm of change and the rhythm of life as generations pass and new ones emerge” (Mead, p. 8).

Although moral rules are designed to endure over time, ethics are not fixed: motives and priorities, and rules must, then, evolve to adapt to new times, new contexts, new constraints, more opportunities. Allott (1991) called this an evolving morality, it has to guide actions in scenarios of disease, famine or natural catastrophes, and we call it resilient ethics. The dynamics of such ethics occur not only in the long term but also in the short term, as was demonstrated during the COVID-19 pandemic. In order to contain the pandemic, populations and most of services across the world had indeed to adopt new rules of conduct in most areas of human activities, within a matter of days. This was not without difficulty and reluctance, but in the end most did comply.

Returning to the topic of disasters, the guidelines provided by the Sendai Framework for Disaster Risk Reduction 2015–2030 (UN, 2015a) and the 2030 Agenda for Sustainable Development (UN, 2015b) are what we ought to follow in order to achieve two inseparable goals: building and strengthening disaster resilience, and achieving the Sustainable Development Goals. From a philosophical perspective, the notion of “what ought to be done” makes the Sendai Framework and the 2030 Agenda

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<sup>8</sup> Collins online Dictionary: <https://www.collinsdictionary.com/dictionary/english-thesaurus/ethics>

like codes of ethics, consisting of ethical guidelines driven by the SDGs<sup>5</sup>, which are then like ethical values as long as they are ideals that we should try to attain.

In summary, ethics of social-ecological communities refer to the values and rules that guide human behavior for the benefit of communities and nature. History shows that such ethics are not static, but adapt to changing times and constraints in both short term and long term.

It is this form of adaptive ethics to conjectural changes requiring behavior adaptation—i.e., a kind of resilient ethics—that we intend to model.

## **2 Modeling Resilient Ethics**

The model here proposed takes concrete form from the idea of resilient ethics that has been introduced at the start of the Covid-19 pandemic (see Rajaonah & Zio, 2020). The model is first described non-formally in terms of content, then introducing formal terminology and a matrix to describe the dynamics of such ethics.

### **2.1 Content of the Model of Resilient Ethics for Disaster**

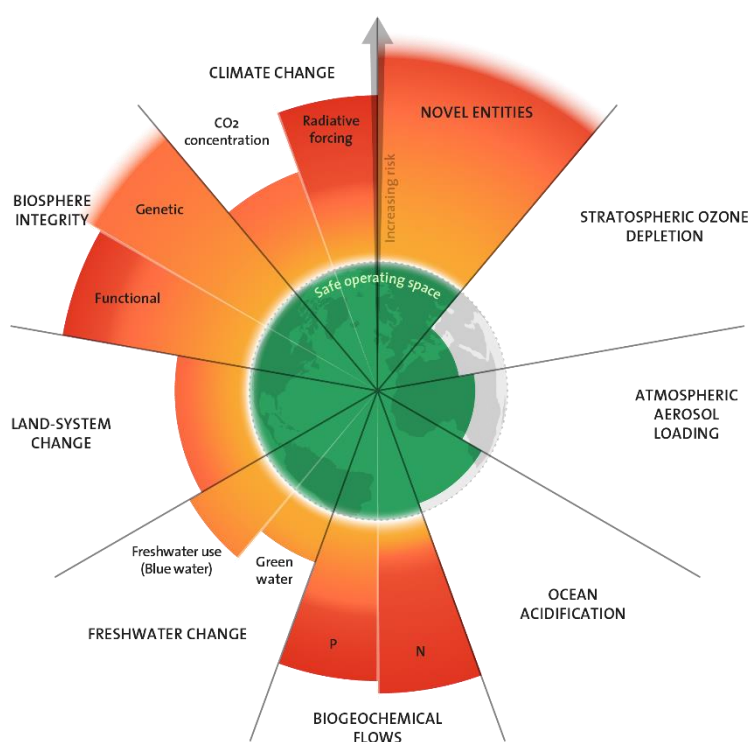
The main ingredients of ethics are principles, that is, according to the dictionary, a set of moral (i.e., good, just or right<sup>9</sup>) rules or standards of behavior<sup>10</sup>. It follows that we consider the main ingredients of the ethics for disaster of a given social-ecological community to be guidelines for behaviors and actions; more precisely, the best actions that can be taken by the community in given space and time, and in accordance with its culture and the local, national and international guidelines related to the interdependent Sendai Framework (UN, 2015a) and the 2030 Agenda (UN, 2015b). The “macro-rule” must be that none of the selected actions cross the planetary boundaries, but rather remain within the green safe operating space shown in Figure 2.

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<sup>9</sup> Collins online Dictionary: <https://www.collinsdictionary.com/dictionary/english/moral>,

<sup>10</sup> <https://www.collinsdictionary.com/dictionary/english/principles>

The concept of planetary boundaries was introduced to provide a qualitative and quantitative framework for decision makers engaged in the process of saving socio-ecological systems, to let them go on existing (see Richardson et al., 2023; Steffen et al., 2015). Control variables materialize the boundaries in terms of risk thresholds not to be transgressed to keep the resilience of the Earth system (see Rockström et al., 2021; Rockström et al., 2023).



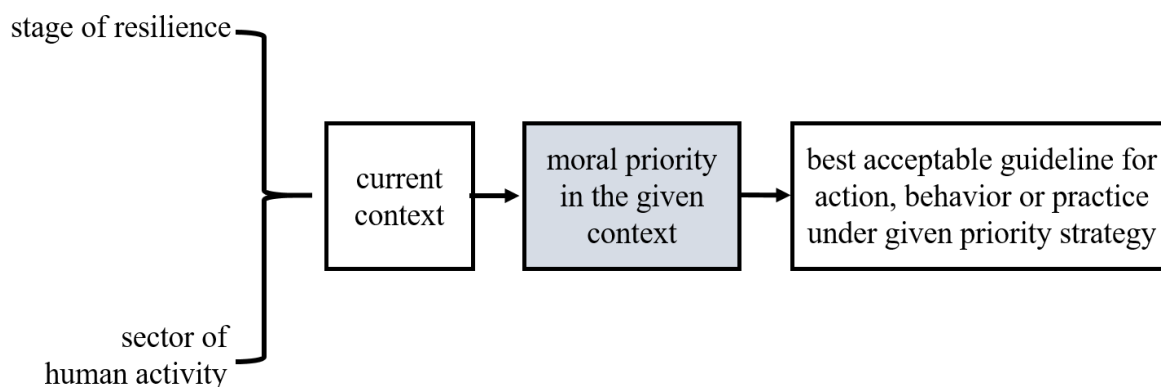
*Figure 2 The 2023 update to the Planetary boundaries. Licensed under CC BY-NC-ND 3.0. Credit: "Azote for Stockholm Resilience Centre, based on analysis in Richardson et al. 2023". Source: <https://www.stockholmresilience.org/research/planetary-boundaries.html> (accessed on 17 July 2024)*

Ethical principles—that are made concrete by guidelines for ethical actions, behaviors or practices—are the first component of the proposed model of resilient ethics for disaster management of social-ecological systems (called thereafter “social-ecological model of resilient ethics”). Other components are for categorizing principles and guidelines in space and time:

- In terms of the spatial dimensions, we consider the main sectors of human activity in communities, which can be the following: health; education; labor; mobility; industry, commerce & finance; environment; institutional governance. These proposed sectors of activity are just examples to illustrate the dynamics in the social-ecological model of resilient ethics.
- In terms of the time dimension, we consider the stages of resilience (Figure 1) as goals to be reached depending on the course of a disaster: plan & prepare; absorb; respond & recover; adapt; transform.

The combination of a sector of human activity and a goal of resilience characterizes the context in a given time and space. Taking into account the diversity of contexts with regard to disaster reduction is at the heart of the dynamics that the proposed model intends to capture. To each context corresponds a moral priority, and to each priority corresponds the best acceptable guideline for action, behavior or practice. For example, one of the moral priorities during the COVID-19 pandemic was to preserve lives around the world, hence the COVAX action to save lives<sup>11</sup> (e.g., Binagwaho, Mathewos, & Davis, 2022).

The proposed social-ecological model of resilient ethics is illustrated in Figure 3.



*Figure 3 The proposed social-ecological model of resilient ethics*

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<sup>11</sup> World Health Organization: <https://www.who.int/initiatives/act-accelerator/covax> (accessed on 2 Sept. 2024)

From now on, moral priority is simplified into “ethical principle,” and guideline for action, behavior or practice into “action”.

Inspired by the Resilience Matrix of Linkov and Trump (2019), the proposed social-ecological model of resilient ethics can be developed in the form of a non-numerical matrix that associates contexts, ethical principles and best acceptable actions. This matrix is the result of the addition of the matrices of ethical principles and of acceptable actions (Figure 6).

## 2.2 Formal Description of the Social-Ecological Model of Resilient Ethics

- Let  $S$  be the set of sectors of human activity:  $S = \{s_i\}$  with  $1 \leq i \leq 7$  :

$S = \{\text{health, education, labor, mobility, industry commerce \& finance, environment, institutional governance}\}$

- Let  $G$  be the set of goals of resilience:  $G = \{g_j\}$  with  $1 \leq j \leq 5$  :

$G = \{\text{plan \& prepare, absorb, respond \& recover, adapt, transform}\}$

- Let  $C_{ij}$  be a particular context during the course of disaster:

$C_{ij} = \{S_i, G_j\}$

- Let  $P$  be the set of ethical principles represented by the  $7 \times 5$  matrix with  $S$  in rows and  $G$  in columns, each principle being the best one in the given context:

$\forall C \exists P : f(C) = P$  with  $P = \{p_{ij}\}$ ,  $1 \leq i \leq 7$ ,  $1 \leq j \leq 5$

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} \\ p_{31} & p_{32} & p_{33} & p_{34} & p_{35} \\ p_{41} & p_{42} & p_{43} & p_{44} & p_{45} \\ p_{51} & p_{52} & p_{53} & p_{54} & p_{55} \\ p_{61} & p_{62} & p_{63} & p_{64} & p_{65} \\ p_{71} & p_{72} & p_{73} & p_{74} & p_{75} \end{bmatrix}$$

*Figure 4 The matrix P of ethical principles, with the sectors of human activity (S) in rows and the goals of resilience (G) in columns*

- Let A be the set of actions represented by the 7 x 5 matrix with S in rows and G in columns, each action being the best acceptable one under the given ethical principle:

$$\forall P \exists A : f(P) = A \text{ with } A = \{a_{ij}\}, 1 \leq i \leq 7, 1 \leq j \leq 5$$

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} \end{bmatrix}$$

*Figure 5 The matrix A of best acceptable actions, with the sectors of human activity (S) in rows and the goals of resilience (G) in columns*

It follows that the proposed model of resilient ethics is in the form of a matrix that results from the addition of the two matrices P and A.

- Let P + A be the result of the addition of the two matrices P and A, represented by the 7 x 5 matrix with S in rows and G in columns, each principle being the best one in the given context, and each action being the best acceptable one under the given ethical principle.

$$P + A = \begin{bmatrix} p_{11} + a_{11} & p_{12} + a_{12} & p_{13} + a_{13} & p_{14} + a_{14} & p_{15} + a_{15} \\ p_{21} + a_{21} & p_{22} + a_{22} & p_{23} + a_{23} & p_{24} + a_{24} & p_{25} + a_{25} \\ p_{31} + a_{31} & p_{32} + a_{32} & p_{33} + a_{33} & p_{34} + a_{34} & p_{35} + a_{35} \\ p_{41} + a_{41} & p_{42} + a_{42} & p_{43} + a_{43} & p_{44} + a_{44} & p_{45} + a_{45} \\ p_{51} + a_{51} & p_{52} + a_{52} & p_{53} + a_{53} & p_{54} + a_{54} & p_{55} + a_{55} \\ p_{61} + a_{61} & p_{62} + a_{62} & p_{63} + a_{63} & p_{64} + a_{64} & p_{65} + a_{65} \\ p_{71} + a_{71} & p_{72} + a_{72} & p_{73} + a_{73} & p_{74} + a_{74} & p_{75} + a_{75} \end{bmatrix}$$

*Figure 6 The model of resilient ethics in the form of the matrix P + A of the best acceptable actions under given ethical principles in given contexts of resilience goals (G, in columns) and sectors of human activity (S, in rows).*

### 3 Conclusions

The main objective of this paper is to make more concrete the idea of resilient ethics by trying to explain it with a model. An interdisciplinary approach has been taken, combining philosophical ideas and mathematical formalism.

#### 3.1 Contributions

The first contribution of the paper is the development of a model that can be a basis for conceiving a tool that aids decision makers in the selection of acceptable and ethical actions to strengthen the resilience of cities communities in the face of disasters (SDG 11).

The second contribution is to have met the challenge of modeling ethics to the level of the main components of ethics, clearly linking ethical principles and expected behaviors. Another contribution is the introduction of a matrix format to represent the dynamics of the model, i.e., the changing relationships between ethical principles and ethical actions following changing contexts over time.

The second and third contributions have made it possible to make concrete the very abstract concept of resilient ethics, which is in itself a contribution to the field of ideas.

#### 3.2 Limitations

The model is conceptually easy to apply, but the difficulty is to find consensual and appropriate ethical principles and guidelines to start with. Here the focus has been on the resilience of “small homogeneous societies” in the context of disaster reduction; confliction behavior is more likely to emerge in large societies (Gert & Gert, 2020), maybe because moral values and priorities depend not only on culture, but also on education and generation (e.g., George & Uyanga, 2014; Payne, Summers & Stewart, 1973).

Another difficulty is in the course of a disaster: how to identify the context, especially the stage of resilience that the community is crossing through. Reducing the diversity of contexts may be a solution by reducing the amount of resilience stages (e.g., considering only before, during, and after the disaster) and/or the extent of the spatial dimension.



### 3.3 Future Work

We have focused on a social-ecological model of resilient ethics in the domain of community disaster resilience, but the model seems to be appropriate for other domains, such as unmanned autonomous vehicles, social robotics for vulnerable people or collaborative robotics in Industry 5.0, which are contexts for which the issue of ethics emerges as essential.

Some difficulties in implementing the model may be overcome with the help of artificial intelligence (AI), for example, to categorize the principles and actions according to the context, or to automatically recognize context and corresponding principles and actions that could be applied. Future studies could therefore be to explore with computer scientists how AI can be used to improve the model.

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