



Research article

Harmony with nature: Disentanglement the influence of ecological perception and adaptation on sustainable development and circular economy goals in country

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ABSTRACT

From the perspective of ecosystem attributes, this research was conducted to explore the impact of people's adaptation and response to their perception of environmental risks on their preference for sustainable development strategies and the realization of a circular economy based on Social Judgment Theory and the Value-Belief-Norm (VBN) theory. To achieve the goal, three substudies were conducted using questionnaire surveys—the first substudy aimed to examine the influence of ecological attributes on environmental risk perception (ERP). The second substudy attempted to understand the intricate connection between ERP and justice, while the third study explored the relationship between justice and SDS (sustainable development strategies) and CEG (realization of a circular economy). The results indicate the following: (1) The first substudy reveals that ecological attributes impact environmental risk perception (ERP), with different environmental values exerting distinct influences. (2) The second substudy suggests that ERP facilitates the realization of social, environmental, and ecological justice, but people's preference for a specific economic growth strategy will affect their tendency to realize justice. (3) The third substudy shows that sustainability strategies (i.e., sustainable production, consumption, and use) mediate the relationship between justice and circular economy goals (CEG). Among the three strategies, sustainable use plays the most significant mediating role. The research outcomes underscore the importance of prioritizing sustainable use in future research in theory and practice.

1. Introduction

The economic development paradigm is a widely used framework among scholars to guide the approach and strategies aimed at achieving economic growth and advancement in a country or region [1]. For a considerable period, the dominant economic development paradigm, which leads to rapid and substantial benefits, has been in place. However, it adversely affects the biophysical environment and human well-being in the long run [2]. The consequences of human-induced environmental damage have become evident, such as the unprecedented heat wave in Europe during the summer of 2022 (United in Science, 2022) and the degradation of biosphere integrity [3]. In response, the circular economy has garnered considerable attention as an alternative economic model to the traditional linear take-make-waste approach [4]. Emphasizing more than just mitigating the negative impact of a linear economy, the

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circular economy represents a systemic transformation that unlocks business and economic opportunities while delivering environmental and social benefits [5]. At present, the influence of the change people makes after perceiving environmental risks on accomplishing circular economy goals has not yet received sufficient attention in circular economy research. Perception is closely related to action. Since human beings can perceive the negative impact of environmental damage, it is assumed that people will explain and respond to the impact when they perceive it, which ultimately facilitates realizing sustainable development and circular economy goals.

From the perspective of ecosystem attributes, this study established a conceptual framework that explains people's adaptive behavior after perceiving environmental risks, i.e., perception, explanation, and response, based on Social Judgment Theory and the VBN theory. Three substudies were conducted in this research. Substudy 1 approached ecological attributes' impact on ERP and environmental values' mediating role. Resilience and vulnerability are the ecosystem attribute that measures environmental performance under pressure. It is predicted that resilience will result in impaired ERP while vulnerability will increase ERP. In the meantime, distinct environmental values attach different weights to nature and man [6]. Therefore, people with different environmental values show differentiated levels of sensitivity to resilience and vulnerability, which moderates the relationship between ecological attributes and ERP. Sub study 2 examined resource dilemmas, subjective well-being after perceiving environmental risks, and justice realization for equitable resource distribution between humans and nature. Different economic growth strategies also differ in the weight attached to economic growth and environmental protection [7]. Therefore, this study delves deeper into the question of whether individuals' preferences for particular economic growth strategies have varying effects on the achievement of social, environmental, and ecological justice. Substudy 3 research into the correlation between justice and the circular economy as well as the mediating role of sustainable development strategies. The sustainable development strategy incorporates the concept of the product life cycle in the hope of realizing efficient use of resources, and the actors at all levels who hold justice follow different sustainable development strategies to facilitate realizing circular economy goals.

2. Theoretical background

2.1. Social-ecological system

The social-ecological system is a biosphere where man and nature are intertwined [8]. As components of the biosphere, man and society rely on its functions and support while shaping it on a global scale and leaving geological imprints on the Earth [9]. Human disturbances, such as deforestation, pollution, and overfishing [10], can significantly alter ecosystem services, which in turn, can impact the ability of the social system to meet human needs. Burkhard et al. (2012) [11], posing a threat to the social system [12] (Berrouet et al., 2018) [12]. If the ecosystem can maintain its functions and services during the disturbance, then the social system is not vulnerable to threats [13]. As a key indicator that measures the threat faced by the ecosystem, vulnerability and resilience largely determine whether the ecosystem can stably provide services when it is disturbed [14]. Therefore, this study approaches the influence of the two ecological attributes on risk perception.

Resilience refers to the extent to which the system can absorb recurrent natural and human disturbances and continue regeneration without slow degradation or accidental transformation into a less desirable state [15]. Ecological resilience is defined as the basic ability of an ecosystem to provide ideal services continuously, even when human beings exploit the environment and make it a fluctuating one [16]. When the ecosystem is forced to exceed the critical threshold, it will suddenly turn into another state; once a fundamental transformation occurs, it will be extremely difficult or even unable to restore the ecosystem to its previous state [17]. In the meantime, human behavior has led the ecosystems to be less able to remain in an ideal state when faced with sudden changes [15]. In terms of providing ecosystem services to society, fragile terrestrial and aquatic ecosystems can easily get into an undesirable state [18].

The vulnerability of an ecosystem refers to the extent of the negative changes made to ecosystem services when the ecosystem is faced with such threats as geological disasters, climate change and land use change [12]. Unlike resilience, vulnerability is the performance of an ecosystem on coping with disturbances [19], namely the ability of an ecosystem to resist disturbances and maintain a specific state [20]. When faced with changes in ecosystem services, people with the least social and economic resources are the most vulnerable because they cannot obtain mental health assistance and disaster relief in most cases [21]. Therefore, the difference among beneficiaries should be taken into account because it will help to design more cost-effective policies and ultimately reduce environmental inequality and maximize social welfare.

2.2. Risk perception and adaptation

Risk perception refers to people's intuitive perception, cognition, prediction and judgment of potential risks in the environment. This process will be affected by their subjective judgment, feelings, and previous experience [22]. ERP refers to the intuitive judgment of individuals or social groups on highly complicated and uncertain environmental problems [22], which plays an important role in predicting individuals' response to environmental risks. Individuals will act to improve the current situation when they perceive adverse situations and do not take the next step until they perceive the surroundings once again when their action leads them to their expectations.

According to Social Judgment Theory, people decide on whether they recognize a new thought or message when they receive it based on their own standpoint [23]. The VBN Theory believes that humans' pro-environmental behavior arises from their values. Therefore, the belief in environmental protection can activate one's awareness of the environmental protection norm, which thus

results in environmental protection behavior [24]. The social-ecological inequality reflected in environmental risks prompts people to reconsider the relationship between humans and nature and take measures to improve its current state. The concept of adaptability describes people's capability to learn, innovate and adjust their responses based on their experience and knowledge so as to adapt to the ever-changing factors, both external and internal [25]. Therefore, humans' adaptation to the ecological environment can be seen as a process in which individuals interpret and respond to environmental risks according to their personal experience and knowledge.

To summarize, when people face a threat or loss caused by ecological attributes, they form a personal perception of environmental risks based on their environmental values, managing to make responses in order to compensate for the losses so caused and adapt to the changes that have not yet occurred. Faced with the impact of uncertain factors in the future, they will meet the circular economy goal through appropriate sustainable development strategies, expecting to achieve the ideal state between humans and nature. Therefore, this study proposes a conceptual framework, as shown in Fig. 1.

2.3. Theoretical analysis

This research will discuss how each substudy contributes to the development of the theory in this study. Three substudies will be conducted based on the following considerations. First, the study will examine the relationship between ecological attributes as antecedents predicting initial stimuli that form environmental adaptation. Folke (2016) [25] suggested that individual adaptability depends on internal and external capabilities. In this study, ecological attributes are identified as resilience and vulnerability, moderated by anthropocentrism and ecocentrism. These will stimulate ERP and subsequently predict justice in substudy two. Thus, the first substudy becomes a significant factor in determining ERP and justice formed by external and internal factors of individuals. The second substudy aims to connect ERP and justice. Environmental risk perception (ERP) and justice are interconnected variables that play a crucial role in the context of economic growth. As people perceive environmental risks, their awareness of environmental injustices and inequalities may become more pronounced. This heightened perception can influence their preferences for specific economic growth strategies, as individuals may prioritize solutions that address these environmental concerns in a fair and equitable manner. The third substudy will explore the relationship between justice and SDS (sustainable development strategies) and CEG (realization of a circular economy). Justice is crucial for effective sustainable development strategies (SDS) and the realization of a circular economy (CEG). It ensures equitable resource distribution and benefits in SDS, promoting inclusive growth. In the circular economy, justice guides policies to minimize inequalities and empower communities for sustainable resource management. Integrating justice in SDS and CEG fosters a fair and resilient path towards a sustainable future.

2.4. Perception of resource dilemmas and pessimistic perspective of future subjective well-being

How to use natural resources has long been deemed as a social dilemma, i.e., a contradiction between short-term personal interests and long-term collective interests [26]. In case of sufficient resource supply, people exploit resources as freely as possible. However, resources are limited and renewed at different speeds, and some are renewed extremely slowly or even non-renewable [27]. When resources are consumed faster than their renewal, a crisis of resource depletion arises [27]. In other words, natural resources are open to human beings, but unchecked exploitation and utilization can lead to resource depletion and environmental degradation. Thus, the Perception of Resource Dilemmas (PRD) is defined in this research as the awareness that resources are limited, resource renewal will not catch up with resource consumption, and eventually, resources will be unable to regenerate if humans make choices that are only favorable to themselves in the short run.

Well-being refers to physical and mental health, material satisfaction, and the sense of dignity and belonging brought by being recognized as a member of society [25]. Research on the relationship between pro-environmental behavior and future subjective well-being shows that when people are aware of the possibility of the living standards declining in the future, they will find ways to improve the current environment in which they live [28], i.e., a negative relationship between future expectations and behavioral trends. This finding further illustrates the significance of constructive pessimism [29] because it can encourage people to realize as soon as possible that the current approach does not work and their capabilities need to be strengthened, thus motivating them to explore better methods and measures faster. Therefore, the Pessimistic Perspective of Future Subjective Well-being (PPFSW) is defined as people's worries about the future prospects caused by environmental pollution and climate change that arise from human activities such as waste discharge, resource abuse, and excessive development.

In this research, resilience is defined as the ability of the ecosystem to continue providing ecosystem services in the face of disturbances [30]. The stronger the resilience is, the less vulnerable the ecosystem will be to environmental damage or the faster the ecosystem will be to restore to the state in which it is able to provide services stably [31]. Due to its restorative capacity, humans are

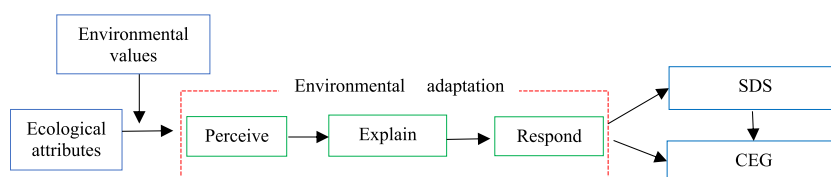


Fig. 1. Conceptual Framework of Ecological and Environmental Adaptation and Its Development. SDS refers to sustainable development strategy, while CEG means circular economy goals.

indifferent to the damage to the ecosystem because they believe that the ecosystem is able to recover from the disturbance and maintain services. In addition, today's environmental problems and governance receive increasing attention, resulting in people's belief that the ecological environment will continue to be improved. This way, people are less uncertain about the ability of the ecosystem to meet humans' current and future needs for their living environment, safety, health and survival, thus reducing their concern about the current and future environment as well as their risk perception. Therefore, the following hypothesis is proposed:

H1a. Resilience has a negative impact on the perception of resource dilemmas.

H1b. Resilience has a negative impact on the pessimistic perspective of future subjective well-being.

Vulnerability reflects the degree to which the capability of an ecosystem to maintain its functions is affected by threats. When an ecosystem is faced with threats, its ecological vulnerability will exert an impact on the change of its ability to provide natural resources and services [12]. The positive feedback from the ecosystem can stabilize its balance and alleviate the impact of the disturbances. The pressure on the ecosystem for a long time may lead to a more fragile balance, which makes the ecosystem more vulnerable to disturbances [32]. The stable provision of ecosystem services is crucial to human survival and development. The more fully people realize the vulnerability of the ecosystem, the more likely they are to be concerned about whether the ecosystem can provide ecosystem services stably at present or in the future. Moreover, people will deepen their understanding of environmental governance and expected results because of their awareness of ecological vulnerability. Therefore, the following hypotheses are proposed:

H2a. Vulnerability has a positive impact on the perception of resource dilemmas.

H2b. Vulnerability has a positive impact on the pessimistic perspective of future subjective well-being.

2.5. Environmental values

People's reflection on the cause of climate change or the perception of involved risks is related to their environmental values, i.e. the way people think about the relationship between humankind and the environment/the Earth [33]. Environmental values refer to one's opinion about the value of the environment [34]. Based on the perspective of looking at environmental problems, environmental values can be divided into anthropocentrism (human-centered) and ecocentrism (nature-centered) [6]. Anthropocentrism is a hierarchical concept about human life, needs and rights, believing that human beings are more important than non-human ones and attaching great importance to nature mainly because of its practical value [35]. Anthropocentrism is in favor of environmental protection because they believe humans' comfort, quality of life and health may depend on a healthy ecosystem and natural resources [6]. Ecocentrism holds the view that all living things have their own intrinsic value, which has nothing to do with their usefulness to human beings [36]. It revolves around the overall impact of environmental improvement or deterioration on the ecosystem, which covers all animals and plants [37]. Ecocentrism emphasizes the connection between man and nature, which is beyond material satisfaction, believing that even if environmental damage has not affected human life, the damage should be restored and protected [6, 38].

Anthropocentrism regards nature as a resource ready for use [39], believing that nature has its moral considerations because the degradation or protection of nature will harm or benefit humans in turn [38]. Compared with the ecosystem's performance under the interference of human activities, anthropocentrism is more sensitive to ecological resilience, namely the ecosystem's ability to continue providing ecosystem services in the face of disturbances [30]. When there is difficulty in meeting the self-needs, human-centered attention and awareness of the consequences caused by environmental damage may lead to a widespread environmental concern [40]. Due to the concern about meeting self-needs and the awareness of the consequences of environmental damage, anthropocentrism weakens the resilience of the ecosystem, namely the negative impact of its ability to maintain stability on risk perception, thus increasing the attention to the current and future environment and risk perception. Therefore, the following hypotheses are put forward:

H3a. Anthropocentrism will attenuate the impact of resilience on the perception of resource dilemmas.

H3b. Anthropocentrism will attenuate the impact of resilience on the pessimistic perspective of future subjective well-being.

Hindering harm and preserving purity have been identified as two separate forms of moral concern of ecocentrism [41]. When biocentrism is focused on avoiding harm, it pays attention to the expansion of personal perception and subjective attribution of others' pain [42]. Biocentrism, which advocates protecting nature purely because it has its intrinsic value, expects the ecological environment to operate at a stable level [43]. Ecocentrists pay more attention to the influence of the disturbance to the ecosystem on the survival of natural animals and plants, whether out to avoid harm or preserving purity. Vulnerability is the performance of the ecological environment when faced with different threats and their resulting negative impacts. Therefore, compared with resilience, ecocentrists are more sensitive to vulnerability, thus positively influencing the impact of vulnerability on the relationship between the perception of resource dilemmas and the pessimistic perspective of future subjective well-being. Therefore, the following hypotheses are proposed:

H4a. Ecocentrism will moderate the relationship between vulnerability and perception of resource dilemmas so that people with high levels of ecocentrism will experience a greater perception of resource dilemmas compared to those with low levels of it.

H4b. Ecocentrism will moderate the relationship between vulnerability and a pessimistic perspective of future subjective well-being so that people with high levels of ecocentrism will experience a greater pessimistic perspective of future subjective well-being

compared to those with low levels of ecocentrism.

2.6. Justice and growth under compensation

Every person is entitled to equal resources so as to maintain a good quality of life [44]. However, with social inequality increasing, the right to meet basic needs for some people has been unfairly infringed upon. That necessitates the re-establishment of justice principles so that victims can get compensation. Compensation means more than offsetting negative phenomena; the compensation for the damage caused is not enough because injustice arises out of various institutions. As a consequence, social justice will not be realized until social differences that lead to injustice, such as privileges and oppression, are examined to weaken their impact on unfair distribution [45]. In this research, compensation is defined as the response to perceived injustice. Specifically, after a structural explanation for the causes of injustice, the principles of justice are reestablished to offset the harm that has been done and to prevent injustice from happening again.

There are mainly three kinds of justice between man and nature: social justice, environmental justice, and ecological justice. The main difference between the three lies in the scope of moral subjects considered. At present, attention has only been directed to human justice, including social justice and environmental justice [46]. However, the growing environmental threat implies that injustice exists not only among humans but also between man and nature. This study believes that people's perception of current injustice will prompt people to reflect on their previous behavior and implicit values and to appeal for justice. This will help to compensate nature and humans for the unfair treatment they have received, thus ultimately achieving sustainable development.

Social justice advocates that all social segments have equal rights to meet their basic needs; Thus, it calls for greater social and economic equality [47]. With social inequality worsening, disaster resilience is also unequally distributed; for instance, poor people are less able to prepare for disasters and recover from them [48]. Environmental justice refers to the distribution of environmental burdens, the acquisition of benefits, and the recognition of people's meaningful participation within environmental decision-making and legal framework [49]. At present, humans' use of nature has done harm to the ecosystem services that are vital to human well-being, which has caused disproportionate negative impacts on different socio-economic groups [50]. Ecological justice refers to the extent to which mankind respects nature when undertaking activities so as to ensure the well-being of non-human species, plants, and natural landscapes; its core lies in the principle of justice that regulates the interaction between man and the natural environment [51]. Baxter (2005) [52] believes that non-human species have the moral right to obtain distributive justice, which necessitates the recognition of their need for a fair share of environmental resources for their survival and reproduction of all life forms [52]. However, the living materials that human beings occupy at the moment threaten the living conditions of other species. In this respect, if ecological justice continues to be ignored, ecological extinction (ecocide) and natural bankruptcy (the bankrupting of nature) are bound to (are doomed to) happen [53].

When people have a sense of urgency caused by the shortage of environmental resources, they expect to redress the unfair distribution among social classes by realizing social justice [54]. In addition, they expect to remove the institutional barriers that hinder people from equally participating in environmental decision-making through the realization of environmental justice [49]. Meanwhile, the realization of ecological justice can ensure that non-human species receive the same treatment as human beings and bear the benefits and costs caused by fair distribution decisions [46], which promotes people to reflect on the previous destruction and neglect of nature and to establish the concept of ecological justice. Based on the above discussion, the following hypotheses are proposed:

H5a. Perception of resource dilemmas positively affects social justice.

H6a. Perception of resource dilemmas positively affects environmental justice.

H7a. Perception of resource dilemmas positively affects ecological justice.

In addition, when people are concerned about their future well-being due to environmental damage, they expect to prevent the damage caused by the unfair treatment of underprivileged groups by achieving social justice [55]. Furthermore, people hope to eliminate the unfair treatment that minorities receive under great environmental pressure by realizing environmental justice [49] so that minorities enjoy the rights and interests of natural resources. Meanwhile, the realization of ecological justice enables the natural environment to be endowed with moral status and its intrinsic value to be recognized so as to achieve more effective protection of nature [46]. Based on the above discussion, the following hypotheses are proposed:

H5b. Pessimistic perspective of future subjective well-being positively affects social justice

H6b. Pessimistic perspective of future subjective well-being positively affects environmental justice.

H7b. Pessimistic perspective of future subjective well-being positively affects ecological justice.

The social ecosystem enables people to achieve prosperity within certain limits, while the limits are determined by the ecology and resources of the Earth [7]. When people pay attention to the unequal use of resources and natural threats, their individual adaptation and response mechanisms differ due to their personal knowledge, experience and/or standpoint. Economic growth, green growth and degrowth are growth strategies with different normative ideals.

The traditional economic theory believes that economic growth is crucial to social welfare [7], expecting to improve the quality of life through the growth of gross national product and believing that economic growth will bring employment, public services, and social stability (International Labour Organisation, ILO).

Different from pursuing economic growth alone, green growth is concerned more with the impact of economic activities on the

environment and manages to achieve economic growth while the environment gets protected [56]. Green growth aims to improve the efficiency of resource use through technical solutions [57] in order to decouple economic growth from environmental impacts and resource use [58]. Despite the gradual improvement in the efficiency of energy and resource use, their consumption is still increasing due to economic growth [57]. Therefore, green growth cannot stop the degradation of the natural environment. In order to reduce resource use, the overall economic activities must be further reduced.

Degrowth refers to the equitable reduction of production and consumption to increase human well-being and improve local and global ecological conditions in the short and long run is defined as “an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level, in the short and long term” [59], which means that degrowth not only focuses on reducing growth but also on achieving human well-being. In the context of economic growth, well-being is simply equated with an increase in consumption. However, degrowth believes that the factors such as social relationships, environmental quality, and health also affect human well-being [60], attaching great importance to the non-material sources of a better life and the significant impact of slower economic growth on improving human well-being [61].

This study argues that even under the same risk perception, the differences in individual interpretation of economic development will affect their choice of environmental protection measures, resulting in different preferences for the realization of ecological justice, environmental justice, and social justice.

2.7. Circular economy goal

The circular economy is an economic system based on business models, which avoids the end of life of a product by means of reducing, reusing, recycling and recovering during the production and consumption process [62]. Kirchherr et al. (2017) [63] summarized four goals of the circular economy, i.e., environmental quality, economic prosperity, social equity, and human well-being. However, current circular economy approaches prioritize the technological, economic and business aspects of constructing the circular economy; this creates economic benefits but narrows down the definitions of social outcomes [64]. Meanwhile, the circular economy has also brought some unexpected consequences. For instance, large forests in Borneo have been cut down, and important habitats of many species have been destroyed to expand the cultivation of palm trees, the raw material of green fuel [65].

Previous studies have noticed the gap in the circular economy in the social dimension, so it has been proposed to incorporate justice into the design of the circular economy system [66]. However, the current attention to justice is limited to justice in human society, and the negative impact of the circular economy on other species is ignored. The neglect of the fairness of the circular economy may lead to recurring or aggravating the unfair relationship arising out of the linear economy [67] or cause further damage to the natural environment and non-human species. In this respect, this study holds the view that ecological justice, environmental justice, and social justice should be incorporated into the circular economy, for compared with simply regarding justice as the product of circular economic activities, practicing justice will help to realize social and ecological benefits of the circular economy better.

Ecological justice can promote people to reduce environmental pollution and make effective use of resources. It expects to maximize the utilization of resources in every aspect of sustainable development and reduce production costs to ensure environmental quality [68]. The essence of environmental justice is about human justice, emphasizing the fairness of human groups, especially underprivileged groups, shouldering the burden of environmental costs [69,69]. Environmental justice expects to sustain the interest of the underprivileged groups through policy fairness; it also expects to reduce environmental costs through sustainable development, thus lowering the environmental costs that people need to bear. In addition, the decreased share of environmental costs also reduces unfairness, and improving the quality of the environment will also promote social equity [70]. Social justice focuses on fairness in the distribution of opportunities, resources, and well-being [46]. To summarize, people's attention and recognition of social justice can improve the distribution of resources in different aspects of social welfare so as to achieve greater fairness among people. Therefore, the following hypotheses are put forward:

H8a. Ecological justice positively affects the circular economy goal.

H8b. Environmental justice positively affects the circular economy goal.

H8c. Social justice positively affects the circular economy goal.

2.8. Sustainable development strategy

Sustainable development refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs [71]. The Life Cycle Initiative by the United Nations Environment Programme has developed a Life Cycle Assessment to assist in decision-making at all levels of product development, production, procurement and final disposal [5, 72]. This way, Life Cycle Assessment integrates sustainable production, consumption and use throughout the whole process to enhance sustainable management of resources, and improve resource efficiency in the production and consumption stages of the life cycle, from resource exploitation to the use and reuse of products and services before waste disposal.

In the implementation of sustainable development, sustainable production is a concept closely related to sustainable development, which refers to the use of pollution-free, energy saving and natural resources, as well as economically feasible, safe and healthy technologies and systems to create goods and services for laborers, society and consumers [73]. Its main goal is to effectively manage scarce resources in terms of social and cultural factors in production [74]. In addition, sustainable production should also take into consideration the features of the products: durable, repairable, easy to recycle, compostable and biodegradable [75]. Moreover,

production usually aims to meet the needs of the consumer market. From the perspective of consumption, sustainable consumption is defined as the use of services and products to meet basic needs and bring about a better quality of life, in which process the use of natural resources and toxic materials and the discharge of waste and pollutants within the life cycle of services or products are minimized, so as not to compromise the needs of future generations [76]. It also indicates that sustainable consumption is to be realized mainly by designing and providing more sustainable products [77].

Although the development strategy of sustainable production and consumption helps to improve the efficiency of resource use, how to maximize the benefits of the used resources and reduce the social disposal costs still needs to be realized when the resources are being used. In addition, the product life can be extended through careful use, repair, upgrade and reuse [77,78]. With sustainable use as a means of sustainable development, people strive to enable used resources to have sustainable utility. This viewpoint avoids excessive consumerism and ensures the integrity of the ecosystem [79]. The perspective of the life cycle emphasizes that consumers should be responsible for products both at the beginning and end of the product life cycle, properly disposing of used goods to maximize their residual value and reducing unnecessary waste to save resources and increase their availability. Therefore, sustainable use is defined as a way ecological. Environmental resources are used repeatedly or continually in a reasonable manner so as to reduce extra resource consumption and promote sustainable development.

2.9. Correlation among justice, SDS and CEG

Inequality per se can be deemed as unsustainable, for it can exert a negative impact on sustainability. Sustainable development not only aims to reduce the disturbance to the ecosystem but to promote human well-being and equity within the ecological stability [80]. When sustainable development policies are being formulated, justice should be taken into account so as to treat the rights between man and nature equally and pay attention to underprivileged groups [51].

Sustainable development focuses on reducing resource use and environmental pollution [82]. Ecological justice attaches great importance to the impact of human production activities on the well-being of the natural environment [82]. It advocates reducing the damage to the environment while maintaining daily human needs [6], which helps people to think about the negative impact of their activities on the natural environment in the process of making production decisions, providing commodities, and choosing lifestyles. When holding the concept of ecological justice, all levels will strive to improve the efficiency of resource use, reduce the discharge of waste, and weaken the impact of the production, selection, use, and disposal of products on the environment. This will help to close material loops in the socio-economic process and reduce the impact of economic activities on the environment. Therefore, the following hypotheses are proposed:

H9a. Sustainable production will mediate the effect of ecological justice on the circular economy.

H9b. Sustainable consumption will mediate the effect of ecological justice on the circular economy.

H9c. Sustainable use will mediate the effect of ecological justice on the circular economy.

Environmental justice believes that everyone, the underprivileged group, in particular, should be treated fairly in the distribution of environmental benefits and costs [46]. When people identify with environmental justice, they expect everyone to share environmental resources and living space on an equal basis, which will promote individuals, enterprises and governments to consider sustainability when they formulate and implement production guidelines and provide and use products so as to improve resource efficiency and reduce waste and environmental pollution. Thus, the environmental costs generated by human activities and shared by mankind decrease, which facilitates improving environmental quality and building a more economically viable and productive society in the long [81]. Producers can increase resource utilization efficiency by promoting clean production, comprehensive utilization of resources, and collaborative disposal of waste [73]. Consumers need to take into account the recycling of environmental protection products and materials to relieve the environmental burden, thus indirectly easing the environmental burden shared by each person and lowering the fairness of the burden distribution. Therefore, the following hypotheses are suggested:

H10a. Sustainable production will mediate the effect of environmental justice on the circular economy.

H10b. Sustainable consumption will mediate the effect of environmental justice on the circular economy.

H10c. Sustainable use will mediate the effect of environmental justice on the circular economy.

Social justice attaches great importance to equal access to opportunities, resources, and welfare for everyone [46]. The recognition of social justice will promote people to consider fairness among human beings when they produce, consume and use resources. Sustainable production (SP) pays attention to the social impact of production activities, emphasizing both the economic efficiency and long-term prosperity of production activities and the contribution or impact of production on social employment [83]. Sustainable consumption (SC) stresses a fair share for everyone, emphasizing that individual consumers cannot compromise others' and the social embeddedness of consumption decisions is accepted [84]. Sustainable use (SU) does not agree with excessive individualism and consumerism. Instead, it underlines the maximization of the surplus value of goods and the reduction of resource waste so as to promote the accessibility of consumer goods for everyone, thus enabling equality between people to be valued and recognized. Therefore, the following hypotheses are proposed:

H11a. Sustainable production will mediate the effect of social justice on the circular economy.

H11b. Sustainable consumption will mediate the effect of social justice on the circular economy.

H11c. Sustainable use will mediate the effect of social justice on the circular economy.

3. Methodology

The research consists of three substudies. Substudy 1 explores the relationship between ecological attributes and environmental risks and the mediating role of environmental values between the two. Substudy 2 approaches the relationship between environmental risk perception and justice and whether different economic-ecological development strategies affect their relationship. Substudy 3 delves into the mediating roles of sustainable production, consumption and use between justice and circular economy goals and whether the roles are different. The research framework is shown in Fig. 2.

During the research, this study administered a questionnaire survey consisting of 56 question items that were developed through a literature review and adjusted to fit the research context. The questions were measured on a seven-point Likert scale, with 1 representing “Strongly Disagree” and 7 representing “Strongly Agree.” To conduct the pre-test, convenient sampling was adopted to the citizens in targeting participants at the entrance and exit of subway stations. In total, this study collected 290 valid questionnaires. As for the sociodemographic variables of the participants in the study, specific details about their age, gender, education level, and other relevant characteristics were collected (Please also indicate one Table for sociodemographic, if possible).

The reliability and validity of the samples were analyzed using the software package SPSS 24.0. In terms of reliability analysis, Cronbach’s α values of all the constructs were greater than 0.7, which means that they met the reliability criterion of 0.7. Therefore, the internal consistency of the questionnaire was good. In terms of validity, the factor loadings of all items for each construct exceeded 0.5, indicating that the questionnaire had a certain level of validity. Based on the above results, a formal test was carried out. Please refer to Appendix A for the pilot study results.

4. Analysis and results

4.1. Substudy 1

A total of 794 valid samples were collected in overall study (Please see Table 1a for general demographic statistics). The primary objective of substudy 1 is to empirically investigate and assess the potential moderating effect of environmental values on the intricate relationship between ecological attributes and individuals’ perceptions of environmental risk. This substudy aims to investigate on how specific ecological attributes, such as resilience and vulnerability, may vary in their influence on environmental risk perception depending on individuals’ environmental values, including anthropocentrism and ecocentrism. The path analysis results are shown in Table 1b. Resilience had a negative correlation with the perception of resource dilemmas ($b = -0.074, p = 0.000$) and with the pessimistic perspective of future subjective well-being ($b = -0.041, p = 0.039$), and the overall impact was significant. On the other hand, the vulnerability had a positive correlation with the perception of resource dilemmas ($b = 0.110, p = 0.004$) and with the pessimistic perspective of future subjective well-being ($b = 0.089, p = 0.018$), and the overall impact was significant. Therefore, the research hypotheses between ecological attributes and environmental risk perception are validated.

Subsequently, the moderating role of environmental values in the relationship between ecological attributes (resilience and

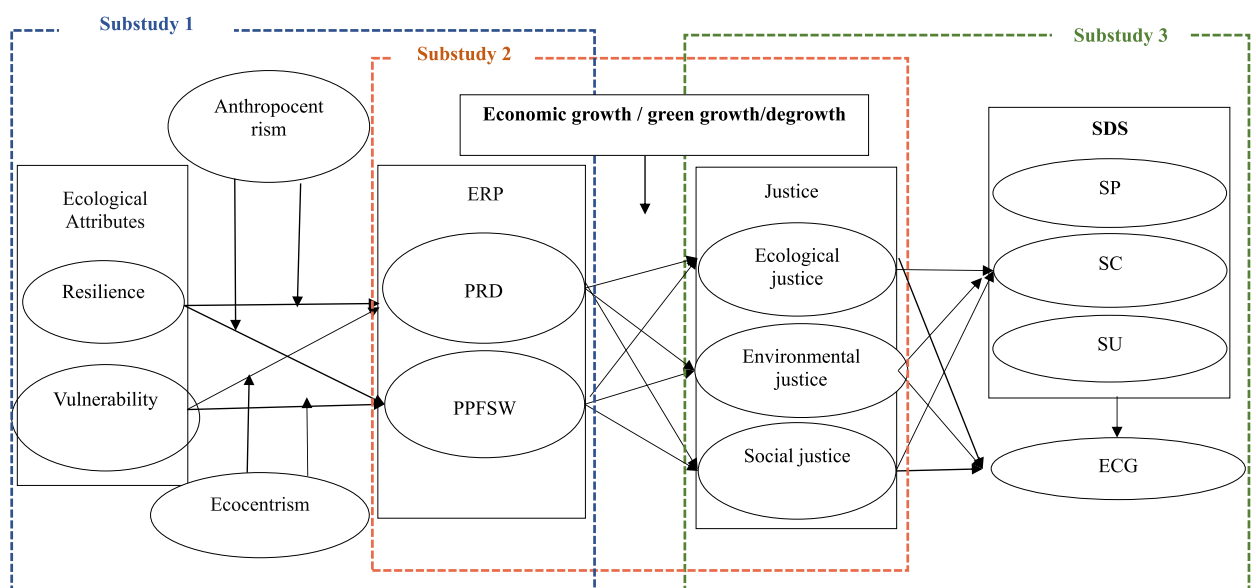


Fig. 2. Research framework.

Table 1a
General demographic statistics.

Statistical Variables	Item	Sample Size (n = 794)	Proportion
Gender	Male	291	36.65
	Female	503	63.35
Age	20 years and below	286	36.02
	21–30	248	31.23
	31–40	108	13.60
	41–50	94	11.84
	51 and above	58	7.30
Education Level	High school and below	79	9.95
	College	144	18.14
	Bachelor's degree	509	64.11
	Master's degree and above	62	7.81

Table 1b
Hypothesis testing results for Substudy 1.

Path	Path Coefficient	Confidence Interval	Hypothesis	Testing Results	P Value
Resilience → Perception of resource dilemma	−0.074	[−0.113, −0.036]	H1a	Validated	***
Resilience → Pessimistic perspective of future subjective well-being	−0.041	[−0.079, −0.002]	H1b	Validated	***
Vulnerability → Perception of resource dilemma	0.11	[0.035, 0.186]	H2a	Validated	***
Vulnerability → Pessimistic perspective of future subjective well-being	0.089	[0.015, 0.163]	H2b	Validated	***
The moderating role of anthropocentrism in the relationship between resilience and perception of resource dilemmas	0.133	[0.100, 0.167]	H3a	Validated	***
The moderating role of anthropocentrism in the relationship between resilience and pessimistic perspective of future subjective well-being	0.157	[0.124, 0.190]	H3b	Validated	***
The moderating role of ecocentrism in the relationship between vulnerability and perception of resource dilemmas	0.087	[0.012, 0.163]	H4a	Validated	***
The moderating role of ecocentrism in the relationship between vulnerability and pessimistic perspective of future subjective well-being	0.089	[0.015, 0.163]	H4b	Validated	***

Note: The symbol "." represents $p > 0.05$, indicating that the result is not statistically significant. The symbol "*" represents $p < 0.05$, indicating statistical significance at the 0.05 level. The symbol "***" represents $p < 0.01$, indicating statistical significance at the 0.01 level.

vulnerability) and environmental risk perception was examined. Firstly, PROCESS Model 1 was employed to test the moderating effect of anthropocentrism. With anthropocentrism as a moderator variable, resilience is found to exert a significant effect on the perception of resource dilemmas ($b = 0.133$, [0.100, 0.167]) and pessimistic perspective of future subjective well-being ($b = 0.157$, [0.124, 0.190]). That suggests the following hypotheses are validated: anthropocentrism plays a moderating role in the relationships between resilience and perception of resource dilemmas and between resilience and a pessimistic perspective of future subjective well-being.

Lastly, PROCESS Model 1 was adopted to test the moderating role of ecocentrism. With ecocentrism as a moderator variable, vulnerability plays a significant role in moderating the perception of resource dilemmas ($b = 0.087$, [0.012, 0.163]) and the pessimistic perspective of future subjective well-being ($b = 0.089$, [0.015, 0.163]). In other words, the following hypotheses are supported: ecocentrism moderates the correlations of vulnerability with the perception of resource dilemmas and with the pessimistic perspective of future subjective well-being. The analysis results are listed in Table 1b.

Substudy 1 shows that vulnerability significantly enhances environmental risk perception while resilience weakens it, so H1a-b and H2a-b are both supported. If people are more aware of the resilience of the ecosystem, people tend to believe that the ecosystem can withstand environmental disturbances and restore to its normal state. Therefore, their perception of resource dilemmas and pessimistic perspective of future subjective well-being are reduced. On the other hand, if people are more aware of the vulnerability of the ecosystem, people tend to be more concerned about the damage to the ecosystem caused by economic and production activities. In addition, the greater the vulnerability, the longer it will take for the ecosystem to recover to the state in which it can provide services normally. Therefore, their perception of resource dilemmas and pessimistic perspective of future subjective well-being are enhanced. Meanwhile, anthropocentrism and ecocentrism will significantly affect the relationship between ecological attributes (resilience and vulnerability) and environmental risk perception. That means H3a-b and H4a-b are validated. Substudy 1 has discussed the impact of ecological attributes (resilience and vulnerability) on environmental risk perception. Since perception and behavior are closely related, this study later discusses the justice needs arising from environmental risk perception and whether it will be affected by different economic and ecological development strategies.

4.2. Substudy 2: environmental risk perception and justice

For Substudy 2, Amos 24.0 was used to examine the relationship between environmental risk perception and justice and explore

whether different economic and ecological development strategies would affect the relationship between environmental risk perception (perception of resource dilemma) and justice. To achieve the goal, the measurement model was evaluated first. In this study, the composite reliability (CR) value of latent variables was greater than 0.7, the AVE value was greater than 0.5, and the construct validity of the model was evaluated by confirmatory factor analysis (CFA). The discriminant validity of the questionnaire is verified by comparing the AVE and the correlation coefficient of corresponding variables. The root of the AVE value is greater than its corresponding correlation coefficient, indicating that the discriminant validity is good. Based on the above indicators, the questionnaire has good convergence validity and discriminant validity, as shown in Table 2 for details.

In addition, this study used AMOS 23.0 to test the model fit. The test results show that the model indicators all fell within the optimal range. Therefore, it can be considered that the model has good goodness of fit. The relevant data are summarized in Table 3 below.

This study used the software package Amos 24.0 to examine the relationships of the structural equation modeling. Table 4 lists the path coefficients of the relationships between environmental risk perception (perception of resource dilemmas and pessimistic perspective of future subjective well-being) and justice (ecological justice, environmental justice and social justice) and the level of significance. It can be seen that all the above correlations are positive and significant. The path coefficients reveal that compared with the pessimistic perspective of future subjective well-being, the perception of resource dilemmas has a greater impact on different kinds of justice. In addition, the perception of resource dilemmas exerts the greatest impact on environmental justice (0.562), while the pessimistic perspective of future subjective well-being has the least impact on environmental justice (0.309).

Subsequently, the collected samples were classified based on the top priority of the three economic and ecological development strategies (i.e., economic growth, green growth and degrowth) for the respondents. Then, the software package Amos 24.0 was adopted to calculate, analyze and compare the coefficients of the path between environmental risk perception (perception of resource dilemma) and justice. This way, the research explored whether the tendency for economic and ecological development strategies affects the impact of environmental risk perception on the realization of different justice. The testing results are shown in Table 4.

When economic development was taken as the priority, there was a positive and significant relationship between environmental risk perception (perception of resource dilemma) and justice. Moreover, the path coefficient of the relationship between the perception of resource dilemmas and social justice and that between the pessimistic perspective of future subjective well-being and social justice are relatively higher, namely 0.464 and 0.460, respectively.

When green growth was taken as the priority, the relationship between environmental risk perception and justice was positive and significant, and the path coefficient of the relationship between the perception of resource dilemmas and environmental justice and that between the pessimistic perspective of future subjective well-being and environmental justice were relatively high, namely 0.440 and 0.399 respectively.

Lastly, the impacts of the degrowth on environmental risk perception (perception of resource dilemma) and justice were examined. The analysis results showed a significant positive impact on the relationship between environmental risk perception (perception of resource dilemma) and justice, of which the path coefficient of perception of resource dilemmas and ecological justice and that of pessimistic perspective of future subjective well-being and ecological justice were relatively higher, i.e., 0.597 and 0.422, respectively.

To sum up, Substudy 2 reveals that the perception of resource dilemmas and the pessimistic perspective of future subjective well-being both exert a significant positive impact on justice. In addition, different economic strategies lead to different tendencies for justice. This result shows adaptability between development strategies and justice from the perspective of the normative ideals of different economic development strategies and moral subjects of different justice, which will be explained in detail in the section Discussion.

4.3. Substudy 3

Substudy 3 aims to verify the mediating roles of sustainable production, consumption and use between justice and circular economy goals, which stresses whether different sustainable development strategies place different degrees of impact. Firstly, this substudy analyzed the mediating role of sustainable development strategies between ecological justice and circular economy goals.

Table 2
Correlation coefficients of variables and validity analysis.

	PRD	PPFSW	Ecological justice	Environmental justice	Social justice
PRD	0.778				
PPFSW	0.672**	0.799			
Ecological justice	0.689**	0.681**	0.787		
Environmental justice	0.693**	0.685**	0.683**	0.775	
Social justice	0.654**	0.676**	0.719**	0.717**	0.770
CR	0.860	0.875	0.867	0.858	0.854
AVE	0.606	0.638	0.620	0.602	0.594
Mean	5.500	5.510	5.780	5.590	5.710
Cronbach's α	0.939	0.959	0.965	0.957	0.950

Note: The diagonal values are the square roots of average variance extracted (AVE) for the corresponding variable. The symbol "." represents $p > 0.05$, indicating that the result is not statistically significant. The symbol "*" represents $p < 0.05$, indicating statistical significance at the 0.05 level. The symbol "**" represents $p < 0.01$, indicating statistical significance at the 0.01 level.

Table 3
The model fit indices and recommended values.

	χ^2/df	GFI	AGFI	CFI	NFI	PNFI	RMSEA
Acceptable Value	< 5	> 0.9	> 0.8	> 0.9	> 0.9	> 0.5	< 0.08
Entire sample	3.616	0.933	0.909	0.980	0.973	0.678	0.057

Source: Bentler, 1989; Byrne, 2001; Gefen et al., 2004; Hair et al., 1998; Joreskog, 2001

Table 4
Path analysis results of Substudy 2.

Path	Ungrouped samples				Economic growth is the priority		Green growth is the priority		Degrowth as the priority	
	(N = 794)				(N = 249)		(N = 303)		(N = 242)	
	Path coefficient	p-value	Hypothesis	Result	Path coefficient	p-value	Path coefficient	p-value	Path coefficient	p-value
PRD → Ecological justice	0.542	***	H5a	Supported	0.403	***	0.264	***	0.597	***
PPFSW → Ecological justice	0.325	***	H5b	Supported	0.414	***	0.384	***	0.422	***
PRD → Environmental justice	0.562	***	H6a	Supported	0.429	***	0.44	***	0.456	***
PPFSW → Environmental justice	0.309	***	H6b	Supported	0.4	***	0.399	***	0.372	***
PRD → Social justice	0.524	***	H7a	Supported	0.464	***	0.335	***	0.381	***
PPFSW → Social justice	0.326	***	H7b	Supported	0.42	***	0.243	***	0.404	***

Note: The symbol "." represents $p > 0.05$, indicating that the result is not statistically significant. The symbol "*" represents $p < 0.05$, indicating statistical significance at the 0.05 level. The symbol "***" represents $p < 0.01$, indicating statistical significance at the 0.01 level.

Regression analysis using PROCESS Model 4 reveals that sustainable production ($b = 0.167$, [0.105, 0.237]), sustainable consumption ($b = 0.149$, [0.050, 0.254]), and sustainable use ($b = 0.203$, [0.124, 0.279]) all had significant mediating effects. It can be seen that the coefficient of the path with sustainable use as a mediator variable is the largest. On the contrary, the path coefficient of the relationship between ecological justice and circular economy goals is not significant. Furthermore, the respective products of the path coefficients of ecological justice and sustainable production, consumption, use and those of sustainable production, consumption, use and circular economy goals were all greater than 0.048. Therefore, the mediating effects of sustainable production, consumption, and use on the correlation between social justice and circular economy goals are verified, which are full of mediating effects.

Subsequently, it analyzed the mediating role of sustainable development strategies between environmental justice and environmental, economic goals. The analysis reveals that sustainable production ($b = 0.150$, [0.094, 0.212]), sustainable consumption ($b = 0.120$, [0.021, 0.228]), and sustainable use ($b = 0.194$, [0.108, 0.273]) all had significant mediating effects. Among them, the coefficient of the path with sustainable use as the mediator variable was the largest. As well, the path coefficient of the relationship between ecological justice and circular economy goals is significant. Furthermore, the respective products of the path coefficients of environmental justice and sustainable production, consumption, use and the path coefficients of sustainable production, consumption, use and circular economy goals were all greater than 0.119. Therefore, the mediating effects of sustainable production, consumption, and use on the correlation between environmental justice and circular economy goals are all verified, which are partial mediating effects.

Table 5
Hypothesis testing results of Substudy 3.

Path	Path coefficient	Confidence interval Bootstrap CI 95%	Hypothesis	Testing results
Ecological justice → CEG	0.480	[-0.042, 0.137]	H9a	Not validated
Environmental justice → CEG	0.119	[0.034, 0.204]	H9b	Validated
Social justice → CEG	0.480	[-0.038, 0.132]	H9c	Not validated
Ecological justice → SP → CEG	0.150	[0.105, 0.237]	H10a	Validated
Ecological justice → SC → CEG	0.149	[0.050, 0.254]	H10b	Validated
Ecological justice → SU → CEG	0.203	[0.124, 0.279]	H10c	Validated
Environmental justice → SP → CEG	0.150	[0.094, 0.212]	H11a	Validated
Environmental justice → SC → CEG	0.120	[0.021, 0.228]	H11b	Validated
Environmental justice → SU → CEG	0.194	[0.108, 0.273]	H11c	Validated
Social justice → SP → CEG	0.139	[0.088, 0.195]	H12a	Validated
Social justice → SC → CEG	0.146	[0.049, 0.253]	H12b	Validated
Social justice → SU → CEG	0.201	[0.118, 0.279]	H12c	Validated

Lastly, it analyzed the mediating role of sustainable development strategies between social justice and circular economy goals. The analysis reveals that sustainable production ($b = 0.139$, [0.088, 0.195]), sustainable consumption ($b = 0.146$, [0.049, 0.253]), and sustainable use ($b = 0.201$, [0.118, 0.279]) all had significant mediating impacts. Among them, the path with sustainable use as the mediator variable had the greatest coefficient. On the other hand, the path coefficient of the relationship between social justice and circular economy goals did not reach the level of significance. Furthermore, the respective products of the path coefficients of environmental justice and sustainable production, consumption, use and those of sustainable production, consumption, use and circular economy goals all exceeded 0.048. Therefore, the mediating effects of sustainable production, consumption, and use on the correlation between social justice and circular economy goals are verified, which are full of mediating effects. Please refer to [Table 5](#) for details of the testing results.

The above results indicate that justice can achieve circular economy goals through sustainable development strategies. The direct paths from ecological and social justice to circular economy goals did not reach the level of significance, while the direct path from environmental justice to circular economy goals was significant. Sustainable production, consumption and use are the manifestations of life cycle management, which can improve resource efficiency and minimize waste. Therefore, with sustainable development strategies as the mediating role, ecological, environmental and social justice can all lead to circular economy goals. Meanwhile, the path coefficient of sustainable use was the largest, suggesting that more attention needs to be directed to sustainable use.

5. Discussion

This study explores the relationship between resilience, vulnerability, and environmental risk perception, while considering the moderating effects of anthropocentrism and ecocentrism. It finds that resilience weakens environmental risk perception, while vulnerability enhances it. Anthropocentrism negatively moderates the resilience-risk perception link, while ecocentrism positively moderates the vulnerability-risk perception link. Both anthropocentrism and ecocentrism play significant roles in shaping individuals' perceptions of environmental risks, indicating varying levels of concern about environmental issues based on different environmental values. These findings offer valuable insights for devising effective strategies to address environmental challenges and promote sustainability while considering individual perspectives. Existing empirical studies have proved that anthropocentrism and ecocentrism encourage people to engage in environmental protection behaviors regardless of their attitude toward the environment [85]. The research offers additional empirical evidence in this regard. The prevalence of environmental issues has significantly impacted human well-being and comfort. Additionally, it has heightened the awareness of anthropocentrists about the vital role of ecosystem stability in ensuring the continuous provision of essential ecosystem services. In practice, no matter what people's attitudes towards the environment are, the impact of the action on the environment and the damage of the environment to human well-being will also prompt people to consider environmental problems more. In real-life situations, people's awareness of environmental issues grows regardless of their initial attitudes toward the environment. This heightened awareness often occurs when individuals witness the consequences of their actions on the environment and the negative impacts of environmental degradation on human well-being. For example, air pollution, deforestation, and overfishing will impact human well-being since the environment changes [86,87].

The perception of resource dilemmas and the pessimistic perspective of future subjective well-being under environmental risks can both direct people's attention to the current injustice and reconsider it [88]. Resource dilemmas and pessimistic perspectives can influence people's attention to environmental injustices [89]. For instance, limited access to vital resources may heighten awareness of inequitable distributions, while pessimistic views on the future may drive urgency to address these issues. These factors act as catalysts, motivating individuals to seek solutions and advocate for positive change. Moreover, the perception of resource dilemmas exerts a greater influence than the pessimistic perspective of future subjective well-being. When economic growth is taken as the priority, compensation for social justice is emphasized. In areas dominated by economic growth, people pay more attention to the satisfaction of their own needs than to the environment and risks, so they are more sensitive to social justice issues like the fair distribution of welfare and opportunities. When people perceive resource shortage and pessimistic future prospects that arise from environmental risks, they expect to achieve equal distribution of resources and welfare through social justice. When green growth is taken as the priority strategy, the compensation for environmental justice is highlighted. People who prefer green growth attach great importance to the healthy development of both man and nature. Thus, they stress both the benefits and costs brought by economic development. When they perceive resource dilemmas and the pessimistic perspective of future subjective well-being, they expect people to make benefits equal costs through environmental justice. In the case of degrowth as the priority, the compensation for ecological justice is underlined. Degrowth pays closer attention to the impact of economic development on the environment; it holds the view that growth is not absolutely necessary, and production and consumption should be reduced as much as possible when the basic needs of human beings are met so as to avoid their negative impacts on natural resources and the environment. Therefore, when those who prefer degrowth perceive resource dilemmas and the pessimistic perspective of future subjective well-being, they expect to achieve sustainable development between humans and nature through ecological justice.

Justice can achieve circular economy goals via sustainable development strategies, and the path coefficient of sustainable development strategies is the largest. Sustainable development not only depends on improving resource efficiency but also on reducing the absolute number of resources used. Current research on sustainable development mainly focuses on sustainable production and consumption, while less attention has been directed to sustainable [5,81]. Despite great improvement in resource efficiency, the amount of resources used is not able to keep global warming below 2°C , a critical threshold [57]. In this respect, this research reveals the importance of sustainable use to sustainable development.

6. Contribution and suggestion

This research investigated the role of ecological attributes, such as resilience and vulnerability, in influencing the public's adaptive behavior when confronted with ecological disruption. For example, communities with high ecological resilience may adopt sustainable production and consumption practices, while those facing ecological vulnerability may exhibit different adaptive behaviors, such as seeking external assistance or implementing resource conservation measures. The Social Judgment Theory and the VBN theory provided a valuable framework to understand these dynamics and offer insights into promoting more sustainable behaviors in the face of environmental challenges. Moreover, it elucidates the influence of justice on sustainable development strategies and circular economy goals in situations involving compensation behavior. Specifically, this research illuminates the interplay between justice and compensation, emphasizing the significance of considering recognition, procedural, and distributive justice to prevent recurring injustice and mitigate past harm. Secondly, the neglect of justice in the circular economy could result in social inequality in the linear economy [67], and overlook the negative impact on biodiversity [90]. Thus, the research proposes justice as a principle. In addition [91], believes that humans should pay attention to the benefits of improving durability in a profligate society, but sustainable use has not received the same attention as sustainable production and consumption. This research confirms the positive impact of sustainable use in realizing the circular economy because sustainable production and consumption do not constitute the entire life cycle of products, and consumers ultimately determine the use and disposal of goods. Due to the importance of sustainable use to the accomplishment of circular economy goals, future research is advised to study the factors that better promote sustainable use.

This study provides some directions for future research. First of all, Substudy 1 explored the impact of resilience and vulnerability on man's environmental risk perception. Human well-being depends on ecosystems, but social systems can still cope with uncertain external risks in various ways. For example, a social system that rewards innovation can withstand multiple external shocks as long as it innovates fast enough [92]. The adaptability of the social system may lead people to be more indifferent to the destruction of the ecosystem. Therefore, future research can develop investigation follow the following research question, how does the adaptability of the social system influence people's environmental risk perception in the context of resilience and vulnerability, considering the potential impact on human well-being and ecosystem destruction? In this respect, future research can test whether the ability of a social system to cope with uncertainties places an impact on environmental risk perception. Then, the circular economy focuses on achieving economic, environmental and social goals through the market and economic means. It has been pointed out that the current research on the circular economy ignores the deficiencies in achieving social and ecological goals [66]. This research proposes to use justice as a means to better accomplish circular economy goals, and future research can focus on attaining circular economy goals in social and ecological dimensions. Finally, scholars like Fang et al. (2007) and Linder et al. (2017) [93][94] argue that the realization of the circular economy necessitates fundamental changes at the micro, meso and macro levels simultaneously [94]. From the perspective of the public (micro), this study clarifies that the adaptation and response of the public in the face of environmental threats are conducive to reaching the circular economy goals. However, individuals often face serious structural constraints and cannot change relevant structures in most cases [84]. Therefore, people's perception of environmental risks is conducive to the realization of a circular economy. After knowing that people's perception of environmental risks is conducive to the realization of a circular economy, future research can explore how governments and enterprises respond to their demand for justice at both the meso and macro levels when people appeal for it, which is an important part of their social responsibility.

7. Research limitations

The research conducted in this paper has certain limitations that should be acknowledged. One of these limitations arises from the innovative and unique nature of the study, which inherently results in lower replicability. It is important for future researchers, including those working on related studies, to focus on improving the replicability of such research endeavors.

Compliance with ethical standards

The author declares that ethics approval and informed consent for animal and human studies are not applicable in this study.

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Data availability statement

Data availability and Institutional Review Board Statement are not applicable in this study.

CRediT authorship contribution statement

Kuei-Feng Chang: Writing – review & editing, Writing – original draft, Supervision, Data curation, Conceptualization. **Cheng-To Lin:** Writing – review & editing, Writing – original draft, Project administration, Funding acquisition, Formal analysis. **Ye-Qi Bin:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e26034>.

References

- [1] A.C. Ferreira, R. Borges, L.D. de Lacerda, Can sustainable development save mangroves? *Sustainability* 14 (3) (2022) 1263.
- [2] A.P. Velenturf, P. Purnell, Resource recovery from waste: Restoring the balance between resource scarcity and waste overload, *Sustainability* 9 (9) (2017) 1603.
- [3] W. Steffen, K. Richardson, J. Rockström, et al., Planetary boundaries: Guiding human development on a changing planet, *Science* 347 (6223) (2015) 1259855.
- [4] EMF, *Towards the circular economy, in: Opportunities for the Consumer Goods Sector, vol. 2, Ellen MacArthur Foundation, 2013. Available via DIALOG, https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-2-opportunities-for-the-consumer-goods-sector.*
- [5] P. Glavič, Evolution and current challenges of sustainable consumption and production, *Sustainability* 13 (2021) 9379, <https://doi.org/10.3390/su13169379>.
- [6] S.C.G. Thompson, M.A. Barton, Ecocentric and anthropocentric attitudes toward the environment, *J. Environ. Psychol.* 14 (2) (1994) 149–157.
- [7] M. Sandberg, K. Klockars, K. Wilén, Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory, *J. Clean. Prod.* 206 (2019) 133–141.
- [8] C. Folke, A. Jansson, J. Rockström, et al., Reconnecting to the biosphere, *Ambio* 40 (7) (2011) 719–738.
- [9] Will Steffen, et al., The Anthropocene: from global change to planetary stewardship, *Ambio* 40 (7) (2011) 739–761, 2011.
- [10] B. Burkhard, F. Kroll, S. Nedkov, et al., Mapping ecosystem service supply, demand and budgets, *Ecol. Indic.* 21 (2012) 17–29.
- [11] L.M. Berrouet, J. Machado, C. Villegas-Palacio, Vulnerability of socio-ecological systems: a conceptual framework, *Ecol. Indic.* 84 (2018) 632–647.
- [12] O.D. Cardona, “Midiendo lo Inmedible” Indicadores de Vulnerabilidad y Riesgo, Instituto de Estudios Ambientales, 2006.
- [13] J. Fiksel, Sustainability and resilience: toward a systems approach, *Sustain. Sci. Pract. Pol.* 2 (2) (2006) 14–21.
- [14] C. Folke, S. Carpenter, B. Walker, et al., Regime shifts, resilience, and biodiversity in ecosystem management, *Annu. Rev. Ecol. Evol. Syst.* (2004) 557–581.
- [15] C. Folke, S. Carpenter, T. Elmqvist, et al., Resilience and sustainable development: building adaptive capacity in a world of transformations, *Ambio* 31 (5) (2002) 437–440.
- [16] A.D. Barnosky, E.A. Hadly, J. Bascompte, et al., Approaching a state shift in Earth’s biosphere, *Nature* 486 (7401) (2012) 52–58.
- [17] C. Folke, T. Hahn, P. Olsson, et al., Adaptive governance of social-ecological systems, *Annu. Rev. Environ. Resour.* 30 (2005) 441–473.
- [18] S. Thakur, V.S. Negi, R. Pathak, et al., Indicator based integrated vulnerability assessment of community forests in Indian west Himalaya, *For. Ecol. Manag.* 457 (2020) 117674.
- [19] F. Brand, Critical natural capital revisited: ecological resilience and sustainable development, *Ecol. Econ.* 68 (3) (2009) 605–612.
- [20] A.L. Huckelba, P.A. Van Lange, The silent killer: consequences of climate change and how to survive past the year 2050, *Sustainability* 12 (9) (2020) 3757.
- [21] P. Slovic, Perception of risk, *Science* 236 (1987) 280–285.
- [22] C.W. Sherif, M. Sherif, R.E. Nebergall, *Attitude and Attitude Change: the Social Judgment-Involvement Approach*, Saunders, Philadelphia, 1965.
- [23] M.H. Azizan, N.A. Wahid, A proposed model on environmental stewardship, *Procedia Soc* 65 (2012) 587–592.
- [24] C. Folke, Resilience (Republished) *Ecol Soc* 21 (4) (2016) 44.
- [25] J. Joireman, Environmental problems as social dilemmas: the temporal dimension, in: *Understanding Behavior in the Context of Time: Theory, Research, and Application*, 2005, pp. 289–304.
- [26] J. Gifford, R. Gifford, FISH 3: a microworld for studying social dilemmas and resource management, *Behav Res Meth Instrum Comput* 32 (2012) 417–422, <https://doi.org/10.3758/BF03200810>.
- [27] K. Naoko, K. Kosuke, Pro-environmental behavior correlates with present and future subjective well-being, *Environ. Dev. Sustain.* 18 (2015) 111–127.
- [28] T. Maldonado, N. Design, *Revolution: toward a Critical Ecology*, Trans. Mario Domandi, vol. 60, Harper and Row, New York, 1972, p. 65.
- [29] F.S. Brand, K. Jax, Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object, *Ecol. Soc.* 12 (1) (2007).
- [30] K. Brown, Resilience, Development and Global Change, Routledge, London, 2016.
- [31] M. Scheffer, S.R. Carpenter, Catastrophic regime shifts in ecosystems: linking theory to observation, *Trends Ecol. Evol.* 18 (12) (2003) 648–656.
- [32] W. Sierra-Barón, O. Navarro, D.K. Amézquita-Naranjo, et al., Beliefs about climate change and their relationship with environmental beliefs and sustainable behavior: a view from rural communities, *Sustainability* 13 (2021) 5326.
- [33] T. Dietz, A. Fitzgerald, R. Shwom, Environmental values, *Annu. Rev. Environ. Resour.* 30 (1) (2005) 335–372.
- [34] H. Kopnina, Neoliberalism, pluralism and environmental education: the call for radical re-orientation, *Environmental Development* 15 (2015) 120–130.
- [35] E.K. Campbell, Beyond anthropocentrism, *J. Hist. Behav. Sci.* 19 (1) (1983) 54–67.
- [36] S.H. Schwartz, J.A. Howard, A normative decision-making model of altruism, *Altruism Helping Behav* (1981) 189–211.
- [37] K.V. Kortenkamp, C.F. Moore, Ecocentrism and anthropocentrism: moral reasoning about ecological commons dilemmas, *J. Environ. Psychol.* 21 (3) (2001) 261–272.
- [38] E. Crist, Abundant earth and the population question, in: P. Cafaro, E. Crist (Eds.), *Life on the Brink: Environmentalists Confront Overpopulation*, University of Georgia Press, 2012, pp. 141–151.
- [39] R. De Young, Expanding and evaluating motives for environmentally responsible behavior, *J. Soc. Issues* 56 (3) (2000) 509–526.
- [40] J. Graham, J. Haidt, S. Koleva, et al., Moral foundations theory: the pragmatic validity of moral pluralism, *Adv in Experimental Social Psychol* 47 (2013) 55–130.
- [41] K. Gray, L. Young, A. Waytz, Mind perception is the essence of morality, *Psychol. Inq.* 23 (2012) 101–124.
- [42] J. Rottman, Breaking down biocentrism: two distinct forms of moral concern for nature, *Front. Psychol.* 5 (2014) 905.
- [43] M. Muneeb Hassan, M. Ameer, F. Jamal, M.H. Tahir, J.T. Mendy, Prevalence of covid-19 among patients with chronic obstructive pulmonary disease and tuberculosis, *Ann. Med.* 55 (1) (2023) 285–291.
- [44] I.M. Young, *Justice and the Politics of Difference*, Princeton University Press, Princeton, NJ, 1990.
- [45] H. Washington, G. Chapron, H. Kopnina, et al., Foregrounding ecojustice in conservation, *Biol. Conserv.* 228 (2018) 367–374.
- [46] G. Foley, *EBOOK: Dimensions of Adult Learning*, McGraw-Hill Education, UK, 2004.
- [47] B.H. Morrow, *Community Resilience: A Social Justice Perspective*, CARRI Research Report, Oak Ridge, TN, 2008.
- [48] D. Schlosberg, Reconciling environmental justice: global movements and political theories, *Environ. Polit.* 13 (3) (2004) 517–540.
- [49] R. Chaplin-Kramer, R.P. Sharp, C. Weil, et al., Global modeling of nature’s contributions to people, *Science* 366 (646) (2019) 255–258.
- [50] R.J. Bies, Interactional (in) justice: the sacred and the profane, *Adv Organ Justice* 89118 (2001).
- [51] B. Baxter, *A Theory of Ecological Justice*, Routledge, New York, 2005.

- [52] A. Wijkman, J. Rockstrom, *Bankrupting Nature: Denying Our Planetary Boundaries*, Routledge, London, 2012.
- [53] T. Jackson, *Prosperity without Growth: Foundations for the Economy of Tomorrow*, Routledge, London, 2016.
- [54] J. Sidanius, F. Pratto, *Social Dominance: an Intergroup Theory of Social Hierarchy and Oppression*, Cambridge University Press, 2001.
- [55] J. Hicckel, What does degrowth mean? A few points of clarification, *Globalizations* 18 (7) (2021) 1105–1111.
- [56] S. Lorek, J.H. Spangenberg, Sustainable consumption within a sustainable economy—beyond green growth and green economies, *J. Clean. Prod.* 63 (2014) 33–44.
- [57] D. O'Rourke, N. Lollo, Transforming consumption: from decoupling, to behavior change, to system changes for sustainable consumption, *Annu. Rev. Environ. Resour.* 40 (1) (2015) 233–259.
- [58] F. Schneider, G. Kallis, J. Martinez-Alier, Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue, *J. Clean. Prod.* 18 (6) (2010) 511–518.
- [59] P. Ariès, *Décroissance Ou Barbarie*, Golias, Lyon, 2005.
- [60] E. Bilancini, S. D'Alessandro, Long-run welfare under externalities in consumption, leisure, and production: a case for happy degrowth vs. unhappy growth, *Ecol. Econ.* 84 (2012) 194–205.
- [61] P. Ghisellini, C. Cialani, S. Ulgiati, A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems, *J. Clean. Prod.* 114 (2016) 11–32.
- [62] J. Kirchherr, D. Reike, M. Hekkert, Conceptualizing the circular economy: an analysis of 114 definitions, *Resour. Conserv. Recycl.* 127 (2017) 221–232.
- [63] N. Ralph, A conceptual merging of circular economy, degrowth and conviviality design approaches applied to renewable energy technology, *J. Cleaner Prod.* 319 (2021) 128549.
- [64] E.B. Fitzherbert, M.J. Struebig, A. Morel, et al., How will oil palm expansion affect biodiversity? *Trends Ecol. Evol.* 23 (10) (2008) 538–545.
- [65] B. Berry, B. Farber, F.C. Rios, et al., Just by design: exploring justice as a multidimensional concept in US circular economy discourse, *Local Environ.* (2021) 1–17.
- [66] M.C. Friant, W.J.V. Vermeulen, R. Salomone, A typology of circular economy discourses: navigating the diverse visions of a contested paradigm, *Resour. Conserv. Recycl.* 161 (2016) 104917.
- [67] M. Geissdoerfer, P. Savaget, N.M.P. Bocken, et al., The Circular Economy—A new sustainability paradigm? *J. Clean. Prod.* 143 (2017) 757–768.
- [68] S. Pauleit, R. Ennos, Y. Golding, Modeling the environmental impacts of urban land use and land cover change—a study in Merseyside, *Landsc Urban Plan* 71 (2005) 295–310.
- [69] J. Korhonen, C. Nuur, A. Feldmann, S.E. Birkie, Circular economy as an essentially contested concept, *J. Clean. Prod.* 175 (2018) 544–552.
- [70] WCED, *Our Common Future: World Commission on Environment and Development*, Oxford University Press, Oxford, 1987.
- [71] A. Remmen, *Life Cycle Management: a Business Guide to Sustainability*, UNEP/Earthprint, 2007.
- [72] G. Piel, *Agenda 21: sustainable development*, *Sci. Am.* 267 (1992) 128, <https://doi.org/10.1038/scientificamerican1092-128>, 128.
- [73] P. Ghadimi, C. Heavey, A review of applications of agent-based modelling and simulation in supplier selection problem, in: 2013 8th EUROSIM Congress on Modelling and Simulation, IIEEE, 2017, pp. 101–107, 2013.
- [74] V. Veleva, M. Ellenbecker, Indicators of sustainable production: framework and methodology, *J. Clean. Prod.* 9 (6) (2001) 519–549.
- [75] Norwegian Ministry for the Environment, *Symposium on Sustainable Consumption*, Norwegian Ministry for the Environment, Oslo, Norway, 1994.
- [76] T. Cooper, Slower consumption reflections on product life spans and the "throwaway society", *J. Ind. Ecol.* 9 (12) (2005) 51–67.
- [77] I.C. Lin, K.F. Chang, A study to explore how disposing old-goods factors influence consumer's behavior, *J. Adv. Manag. Sci.* 1 (4) (2013).
- [78] M. Hutton, N. Leader-Williams, Sustainable use and incentive-driven conservation: realigning human and conservation interests, *Oryx* 37 (2) (2003) 215–226.
- [79] V. De Marchi, Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms, *Res. Policy* 41 (3) (2012) 614–623.
- [80] L. Akenji, M. Bengtsson, Making sustainable consumption and production the core of sustainable development goals, *Sustainability* 6 (2) (2014) 513–529.
- [81] A. Naess, The shallow and the deep: long-range ecology movement: a summary, *Inquiry* 16 (1973) 95–99.
- [82] R.A. Easterlin, Happiness and economic growth—the evidence, in: *Global Handbook of Quality of Life*, Springer, Dordrecht, 2015, pp. 283–299.
- [83] S. Lorek, D. Fuchs, Strong, sustainable consumption governance—precondition for a degrowth path? *J. Clean. Prod.* 38 (2013) 36–43.
- [84] K. Kaida, Facilitating pro-environmental behavior: the role of pessimism and anthropocentric environmental values, *Soc. Indic. Res.* 126 (3) (2015) 1243–1260.
- [85] K. Aruga, Economics and cross-regional environmental problems, in: *Environmental and Natural Resource Economics*, Springer International Publishing, Cham, 2022, pp. 87–113.
- [86] T. Sterner, E.B. Barbier, A.S. Crépin, Spreading environmental economics worldwide, *Environ. Resour. Econ.* 84 (3) (2023) 649–657.
- [87] J. Li, S. Yu, Z. Xu, Does environmental pollution weaken the positive effect of government public expenditure on residents' subjective well-being? A case study in China, *Energy Environ.* 34 (4) (2023) 927–945.
- [88] C. He, S. He, E. Mu, J. Peng, Environmental economic geography: recent advances and innovative development, *Geogr. Sustain.* 3 (2) (2022) 152–163.
- [89] J. Buchmann-Duck, K.F. Beazley, An urgent call for circular economy advocates to acknowledge its limitations in conserving biodiversity, *Sci. Total Environ.* 727 (2020) 138602.
- [90] K.E. Boulding, The economics of coming spaceship earth, in: H. Jarret (Ed.), *Environmental Quality in a Growing Economy*, John Hopkins University Press, Baltimore, MD, 1966.
- [91] J.M. Anderies, M.A. Janssen, E. Ostrom, A framework to analyze the robustness of social-ecological systems from an institutional perspective, *Ecol. Soc.* 9 (1) (2004).
- [92] Y. Fang, R.P. Côté, R. Qin, Industrial sustainability in China: practice and prospects for eco-industrial development, *J. Environ. Manag.* 83 (3) (2007) 315–328.
- [93] M. Linder, M. Williander, Circular business model innovation: inherent uncertainties, *Bus. Strat. Environ.* 26 (2) (2017) 182–196.