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Quintuple Helix Lens for Transformation: An Okayama Model of Education for Sustainable Development

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What transforms society? Using the quintuple helix model (QHM) of social innovation, this study examines how the Okayama Education for Sustainable Development (ESD) project has transformed the local community and its people, and how this has led to global recognition. Okayama is known as a world leader in ESD and their unique approach is called the Okayama Model of ESD. This study further looks at the institutional configuration on the elements contributed to knowledge co-creation and how the key actors interacted to contribute to societal transformation through knowledge, social innovation, and institutional setting. The goal of this study is to outline the Okayama Model of ESD using the QHM lens constituted of five helices; education, politics, society, economy, and the natural environment. This study applies a qualitative research method, in which key actors who contribute most to the development of the Okayama Model of ESD are identified by content analysis and semi-structured interviews that are conducted using the life history method. The result shows that the firm ground of the political subsystem facilitates the interaction among the stakeholders in the three subsystems–education, social, and natural environment, which ultimately contributes to the joining of the economic subsystem and the initiation of the knowledge circulation process. Transformation necessitates a city-wide approach involving a network of multiple actors to collaborate for knowledge co-creation and circulation, and the establishment of a new social values system. The study revealed several key points of local action that accelerated the transformation process by helping in value creation, knowledge convergence, and system interaction, which was instilled early through all forms of education—multiple actors' interaction that shapes through the ESD project that stimulates the triangulation of mind, hearts, and hands. This way, the city of Okayama functions as a living laboratory for the Okayama Model of ESD. This situation naturally promotes Mode 3 of the knowledge co-creation system, and the principles of civic collaboration and citizen engagement developed through the Okayama Model of ESD have been elaborated in the prefecture-wide vision statement.

Keywords: Education for Sustainable Development, quintuple helix model, knowledge, social education, transformation

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INTRODUCTION

Providing an enabling environment for transformation is crucial to attain a sustainable society. The quintuple helix model (QHM) is one of the frameworks that promotes knowledge and creativity as valuable resources in the development of society (Carayannis et al., 2012). The framework includes five key domains—education, politics, society, economy, and the natural environment—that represent the actors in society and drive the transformation in response to the anthropogenic challenges of global warming. As a result, QHM is used in a systemic change mode to shift from technological to social innovation (Franc and Karadžija, 2019; Fazey et al., 2021). Beginning with the emergence of the triple helix system's knowledge economy, society's transformative approach evolved into the quadruple helix system, which relates to knowledge society and knowledge democracy, and later on into the QHM system, which refers to a broader perspective of socio-ecological transformations and the natural environment (Campbell et al., 2015). The European Commission has mentioned this socio-ecological transition as the future roadmap of development (Carayannis et al., 2012). This is where social innovation becomes one of the most important elements in development strategies. The model's interactive mode enables knowledge exchange and co-creation in a transdisciplinary approach (Carayannis and Campbell, 2010) by integrating public opinion in knowledge development, creative industries, politics, lifestyles, culture, values, and norms (MacGregor et al., 2010; Sunina and Rivza, 2016). However, the interaction that results in the transformation of society is yet to be caught elsewhere.

Education for sustainable development (ESD) is defined by Wals and Kieft (2010) as "a vision of education that attempts to reconcile human and economic wellbeing with cultural traditions and respect for the Earth's natural resources." This broad definition emphasizes several learning aspects of ESD, such as future education, citizenship education, education for a culture of peace, gender equality and respect for human rights, health education, population education, education for protecting and managing natural resources, and education for sustainable consumption. Further, ESD was developed to assist communities in developing their sustainability goals or action plans based on educational change (Arbuthnott, 2009), while the ESD toolkit was developed to assist communities in developing their sustainability goals (McKeown et al., 2002). There is a need for a systemic approach to accelerate the entire transformation process in society (Brennan, 1997) by involving multiple domains—social, political, cultural, and technical (Hölscher et al., 2017). Besides, it is difficult to develop tools and methods to capture change across such wide-ranging domains (Williams and Robinson, 2020) and over long time periods (Schot and Kanger, 2018). This study tries to demonstrate the gaps using QHM for the homegrown practices of the Okayama Model of ESD.

The Okayama Model of ESD is a concept and term that has got widespread recognition and been used as a result of the unique nature of the Okayama ESD project, a joint public–private initiative. The Okayama ESD project is based on the principle of engaging all citizens in an integrated approach. The model received the UNESCO–Japan Prize for ESD in 2016, which honors and showcases outstanding and innovative ESD projects and programs within the framework of the Global Action Programme on ESD (GAP) (UNESCO., 2017b). The model describes various actors' involvement such as a network of schools, community learning centers (Kominkan in Japanese), the government, corporations, NGOs, and other civil society organizations. However, none of the research studies the actors' interaction in a systemic way.

The city is also involved in the global network of regional centers of expertise (RCEs) for ESD governed by United Nations University, Tokyo, Japan (Mochizuki and Fadeeva, 2008). "RCE Okayama" plays a crucial function by working actively with the local stakeholders across the network. Regarding how this "Okayama Model" promoted by RCE Okayama has penetrated into the local community, the Okayama ESD Promotion Commission—the promoting body of RCE Okayama—suggests that there was a unique and considerable effort at the beginning of the project to link school education and social education with the diverse practices that already existed in the community. From Usami (2017), it can be seen that this was due to the fact that the project's secretariat office was located within the local government—Okayama City Council—as the ESD Promotion Division, and the local government actively provided financial and human support to involve businesses, schools, and citizens' groups. In other words, the city has made ESD a public project, which has broadened the vision of ESD and made it possible to involve more citizens, leading to transformation. For ESD to spread this way, people's sense of urgency about the sustainability of the earth is considered to be an important driving factor. However, as the Okayama prefecture is one of the least disaster-prone areas in Japan and is blessed climatically, naturally, and culturally, it is a contradictory situation that the general public's sense of urgency about sustainability is low. After World War II, the industrial structure of the region changed dramatically, and lifestyles have rapidly become more urbanized, leading to considerable changes in the way they interact with nature. In this sense, this study suggests that the Okayama Model of ESD has the potential to be more universal and versatile.

In the current context of sustainable development goals (SDGs), quality education (SDG No 4) or ESD has been stated under Target 4.7 (UNESCO., 2017a). ESD has been announced as a key enabler to the 17 SDGs toward 2030 with special attention to individual transformation, societal transformation, and technological advances (UNESCO., 2020). The emphasis on the five priority actions is advancing policy, transforming the learning and training environment, developing the capacity of educators and trainers, mobilizing youth, and accelerating sustainable solutions at the local level. Therefore, it is necessary to analyze whether and how the Okayama Model of ESD relates to and accelerates these priority actions, and if not, why not. SDG 4.7 is as follows:

> "*By 2030 ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace*

and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development."

The emphasis of QHM on knowledge and social innovation as the most essential resources entails significant collaboration of players that create a platform for knowledge co-creation. This is aligned with the spirit to achieve sustainable development and combat climate change. In the sustainable transition phase, QHM places a strong emphasis on the interaction of nature and environment as the focal point of society's transformation. This transformational mindset is congruent with the objective of ESD.

LITERATURE REVIEW

Some parts of transformation that took place toward the sustainable society of Okayama from various perspectives of ESD have been demonstrated in several studies. This includes institutionalization of lifelong education in Japan by local government (Maehira, 1994), high dependency of development of ESD initiative to the relevant Ministries—Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and the Ministry of the Environment (Nomura and Abe, 2010), reorienting education toward sustainable education (Clark et al., 2020), review of ESD implementation in higher education institutions (Kitamura and Hoshii, 2010), and the emergence of the Japanese ESD movement (Nomura and Abe, 2009). These studies explain the formal education contribution of ESD in the Okayama prefecture. However, none of them identify the actors' contribution to the city's transformation process toward a sustainable society in the lens of QHM as a transformative approach, which shares the same agenda with ESD. QHM becomes a framework of societal ecological transformation in addressing the 21st century climate change crisis, which is part of the societal transformation (Feola, 2015).

The expansive economic growth and development brings its consequences and questions how sustainable the society is. Several local studies in the Okayama region highlighted how the environment affects the waste generation rate (Matsui, 2015), uranium contamination (Yamamoto et al., 1974), searching final waste disposal method (Na et al., 2007), and presence of microplastic (Yamamoto et al., 2021), which portray the local challenge. Those studies briefly describe the state of sustainable society that requires the social actor's contribution to solve the problem. Action-oriented research was documented in several studies covering topics such as conservation of waste cooking oil (Yang et al., 2017), sustainable energy policies (Izutsu et al., 2012), improving rural connectivity through information technology (Fujinami, 2017), marine conservation programs (Sakurai and Uehara, 2020), fishers' conservation (Tsurita et al., 2018), and forest vegetation for conservation (Ohta and Hada, 2012). Concern on a sustainable future through ESD has been raised by recognizing the key sustainable development issues. The key issues are climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption (Leicht et al., 2018). Those natural forces are part of the transformation of society. However, those studies do not identify the key actors' involvement in mobilizing action performed by the communities in Okayama. This part is crucial in leading societal transformation through transformative learning.

According to Jack Mezirow's adult transformational learning theory in the 1980s, the transformation aimed to be a comprehensive, idealized, and universal model comprising the general structures, elements, and processes of adult learning. Culture and situations determine the structure's elements and process, which are constructivist to the learner's interpretation and reinterpretation in producing meaning and learning through their sense of experience. These theories of lifelong learning and adult learning have been accepted in social education in Japan, and they have been reflected in the Kominkans that have been established to realize these principles. In particular, Okayama City is the town with the most active social education system in Japan, and its Kominkans are known as good models that have developed many learning activities based on this philosophy. The Okayama ESD project has developed around Kominkans, and it goes without saying that Mezirow and other theories of experience-based learning and transformative learning are fundamental to the learning theory that underpins the project. The initiative came to complement the existing formal education system, such as schools and the university. Therefore, it can be said that the model establishes a learning environment for transformation that fits into the QHM's sociocultural domain (Carayannis and Campbell, 2018). The Okayama ESD Promotion Commission that promotes the projects entails collaborative interaction among several parties or stakeholders, including administrative entities, citizens' groups, non-governmental organizations (NGOs), and higher education institutions (Abe and Habu, 2009). Yet, it is unclear how societal engagement occurred.

In the name of transformation, various forms and levels of education are required to support societal transformation. The individual level of transformative learning of adult learners, outlined previously by Mezirow (1994), advances to a Communities of Practice (CoP) where people with the same concerns and interests interact regularly (Wenger, 1998); further, the transformation requires a platform for social learning or social education (Wals et al., 2017). Here, there is a shift from teaching to learning (Kolb and Kolb, 2005) beyond formal education through experiential learning, which can bring new ideas and behavior for change (Craps and Brugnach, 2021). To support that, it is necessary to create a social environment that encourages transformation beyond formal education or non-formal education (NFE). This is coined as lifelong learning, which is vital for the transformation of society.

QHM provides the potential for knowledge creation and creativity (Carayannis et al., 2012, 2017), and social (societal) interactions (Carayannis and Campbell, 2010) in a specialized environment (Baker and Mehmood, 2015). This is to catalyze the development of new technologies, knowledge, and societal transformation (Grundel and Dahlström, 2016). It demonstrates how intricately interwoven civilization and nature are. The social innovation component encourages collaboration to address social problems through innovative community activities and is linked to societal performance and innovation (Franc and Karadžija, 2019). The phrase "social innovation" is based on

an earlier definition of traditional innovation as "the doing of new things or the doing of things that are already being done in a new way" (Schumpeter, 1947). New solutions (products, services, models, markets, processes, and so on) simultaneously meet a social need (better than existing solutions) and lead to new or improved capabilities and relationships for better asset and resource utilization (Murray et al., 2010). Social innovations are beneficial to society and increase society's power to act. However, the process of producing social innovation may need iterative action, reflection, and deliberation of individuals and groups of effort. This is where they need to engage in sharing their experience and ideas to solve complex challenges collaboratively. This is termed as social learning (Diduck et al., 2005; Keen et al., 2005).

The social component of the QHM paradigm aims to capture community and public-based media participation in knowledge co-creation. The (societal) interchange and transfer of knowledge outside of schooling subsystems constitutes the social and collaborative learning dimension (Barth, 2011). This platform extends the linear model of invention that has been utilized for decades in basic research (Narin et al., 1997). From the formal education mode that allows transdisciplinarity through a campus living lab (Zen, 2017; Zen et al., 2019), this interaction of a non-linear innovation model collects several types of information in transdisciplinary research beyond formal education, which facilitates Mode 3 of knowledge co-creation (Grundel and Dahlström, 2016; Provenzano et al., 2016; Franc and Karadžija, 2019; Durán-Romero et al., 2020). However, few articulated how the various expertise and know-how are employed in the context of the QHM framework.

There is a link between knowledge co-creation, various actors' involvement, and the mode of education underlying the aspiration of QHM that is yet to be explained. Several pedagogical approaches that relate to knowledge co-creation are found in the informal learning process (García-Peñalvo et al., 2013) and learning through experiential learning (Tanaka et al., 2016). Moreover, several modes of involvement—that is, community participatory video (Tremblay and Jayme, 2015), stakeholder engagement for water planning (Graversgaard et al., 2017), and collaborative water governance—provide a platform for interaction but are yet to explain how this interaction takes place. These approaches have a transformative component that can be used to transform society. However, a study that demonstrates how the whole society transforms is yet to be found elsewhere.

The term "social-ecological transition" refers to recent political, financial, and cultural changes that have resulted from efforts to address the social-ecological crisis. The dilemma of the 21st century, which includes climate change, biodiversity and ecosystem loss, artificial intelligence, obesity, pandemic, and their intersection (IPBES, 2018; IPCC, 2018), requires rapid action on the part of people and society as a whole. Effective and systemic changes are required to inspire fundamental changes at the individual, community, and societal levels. How institutions adapt by creating the conditions for social learning is rarely emphasized (Armitage et al., 2011). Emphasis on changes in the way actors interact is also required (Clark et al., 2020), especially on how humans interact with nature in the context of socio-ecological systems through consistent practice and collective action within certain geographical concern (Anderies et al., 2004). Community participation in solving issues through science or Citizen of Science (Calabrese Barton, 2012; Pykett et al., 2020) shows the contribution of the scientific community toward creating a social learning environment in a more participatory fashion. Therefore, the social consequences of various efforts to change captured in the sustainability transition smooth the transformational changes (Williams and Robinson, 2020).

The four key thrusts of Agenda 21 are public awareness and knowledge access to high-quality basic education; reorienting existing education and all-sector training, which also enhances the cognitive, social, emotional, and behavioral dimensions of learning as a holistic and transformational change that encompasses learning content and outcomes; pedagogy; and the learning environment itself (UNESCO., 2014). QHM also serves as a framework for transdisciplinary analysis of sustainable development and social ecology, with its application viewed as a transition from technological to social innovation (Franc and Karadžija, 2019) in a systemic change mode (Fazey et al., 2021) by integrating public opinion in knowledge creation, creative industries, politics, lifestyles, culture, values, and norms (MacGregor et al., 2010; Sunina and Rivza, 2016). The incorporation of public opinion into knowledge co-creation processes is consistent with the ethos of knowledge democratization toward a knowledge-based society and a knowledge-based democracy (Carayannis and Campbell, 2009). As a result, information becomes inclusive and becomes a part of the process of societal development.

In this paper, we aim to outline the Okayama Model of ESD using the QHM lens contributed by their five helices; education, politics, society, economy, and the natural environment. This work discusses the following: (i). how the various actors represented in the helices interact and contribute to the transformation of the city through ESD implementation in formal and non-formal education; (ii). how the political domain contributes to sustainable governance to facilitate transformation of the society; and (iii). how the community at their level addresses the local issues related to the natural environment and what are the economic factors that contribute to the long-term transformation of society. Such initiatives would bolster the socio-ecological shift that is occurring in tandem with local concerns.

MATERIALS AND METHODS

Okayama City, located on the north shore of the Seto Inland Sea in Japan, is a major hub of education, social welfare, culture, medical services, and transportation in West Japan (**Figure 1**). The city has a population of approximately 700,000 and an area of 790 square kilometers (**Figure 2**), which is blessed with abundant water and greenery. Another core point is its acknowledgment by the United Nations University as one of the seven initial Regional Centers of Expertise on ESD (RCEs) in the world in 2005. The goal of RCE Okayama is to promote ESD, which

reflects the nature of the region; and to create a community where people learn, think, and act together, through interaction and cooperation between people involved in ESD within and outside the region. Multiple individuals and organizations such as schools, universities, Kominkans, NGOs/NPOs, enterprises, and administrations implement ESD with themes of natural environment, international understanding, community development, agriculture, food, energy, and so on (UNESCO World Conference on ESD, 2005).

The QHM framework consists of five actors or domains identified as follows: (i). the education system, which generates and disseminates new knowledge; (ii). the economic system, which controls, possesses, and generates economic capital; (iii). the political system, which has political and legal capital (e.g., laws, clearances, policy, public goods); (iv). media-based & culture-based public civil society, which has social capital, and is characterized by traditions, values, and behavioral patterns; and v. the natural, which has natural capital (e.g., natural resources, climate, air quality, and geological stability) (Carayannis et al., 2012) (**Figure 3**).

FIGURE 1 | Map of Japan.

FIGURE 2 | Okayama city in Okayama prefecture.

This study's qualitative technique comprises semi-structured interviews with key actors prior to the introduction of the UNESCO Okayama Model of ESD in 2016. This is to go deeply into issues that have been encountered and perceived (McGrath et al., 2019). People participating in the ESD project were interviewed about their role during Okayama's transformation phase toward sustainability. The link between the scholars involved in this process and the key actors emphasizes the examination of human phenomena and the naturalistic paradigm of the transformation. The inclusion of actors, including laypeople and practitioners, contributes to the study's transdisciplinary nature (Mobjörk, 2010) and participatory action research strategy (Thiollent, 2011). It is believed that developing the research process with the help of these two groups will result in robust research output with practical and theoretical implications. Their findings will supplement the scientific findings from the desktop study, which used content analysis as an inductive approach. Furthermore, content analysis employs the Okayama Model of ESD, which contributes to the QHM framework for the creation of a conceptual framework or categories (Elo and Kyngäs, 2008).

Interview

The study interviewed the following six actors who have been involved with the Okayama ESD project from the beginning, between October 2020 to February 2021. The process of selecting interviewees, that is, identifying key actors of the project, was based on the desktop surveys and literature review. The list of interviewees is presented in **Table 1**. Researcher involvement in ESD-related projects with Kominkans, school activity, and Okayama University helps robust data gatherers with the observation during the study. This process allowed the study to develop a deeper and fuller understanding of how the Okayama Model of ESD may affect community life in general and the knowledge co-creation at large. Field observation, which is part of the researcher's work as a professional staff member at the ESD Promotion Center of Okayama University, and involvement with several schools' ESD-related projects help to understand a broader perspective of the QHM.

RESULTS

The results section is outlined based on the following questions: (i). How do the actors in the Okayama Model of ESD interact to implement the ESD project? (ii). What are the initiatives being executed up to today? (iii). How does each of the domains play its role and functions in the context of QHM? and (iv). How has the co-creation of knowledge and values taken place?

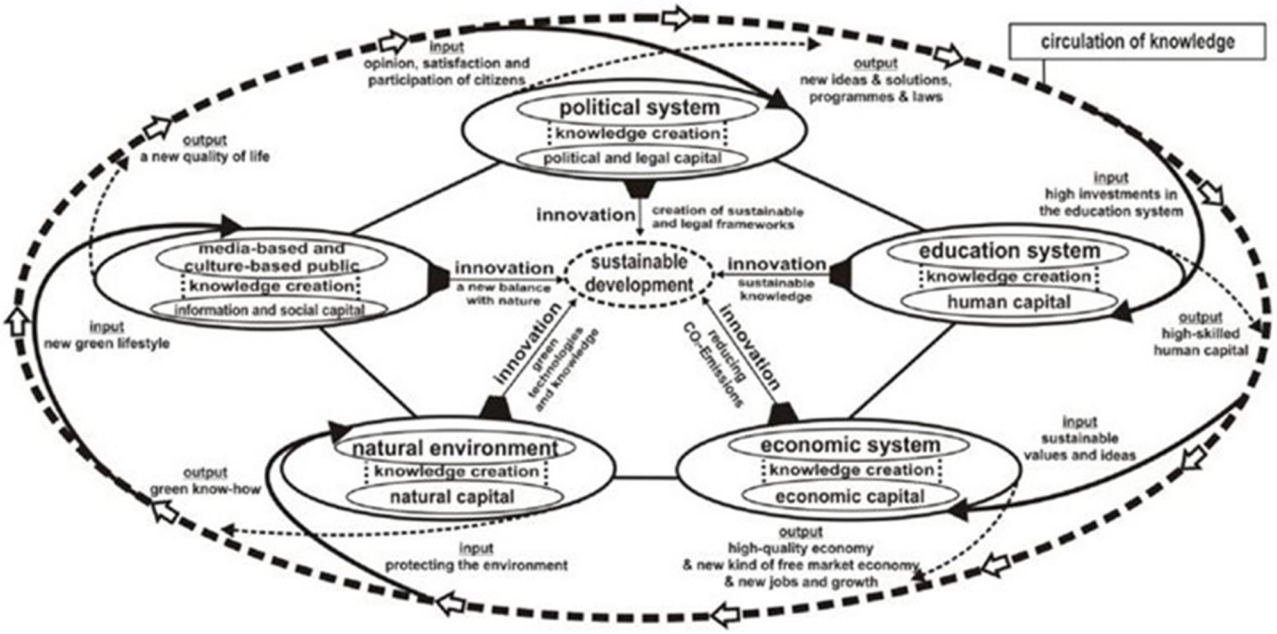

FIGURE 3 | Quintuple helix model and its five subsystems.

Interview Results

In general, the study outlines the results from the interviews according to key actors who represent the system of QHM—their interaction in and contribution to the transformation process of the Okayama Model of ESD. The interviewee's experiences involved in the Okayama Model of ESD were used to validate the main finding. The synthesis from the main finding is explained in **Table 2**.

The Environment Preservation Department—the Environment Bureau of Municipalities of Okayama City—represents the political domain or sub-system of QHM. The facilitation of the Environmental Bureau to the residential association strengthened by the establishment of the Law for the Promotion of Nature Restoration enacted in December 2002 provides a framework for nature restoration projects implemented through the participation of various local actors. This regulation connects the existing organizations and people dealing with these issues together to promote citizens' awareness and action for environmental issues. Here is how the government plays its roles in educating the public while allowing the co-creation of knowledge and values. This effort was combined with the financial and technical support provided through a framework titled "Environment Partnership Project: EPP" in 2001. Hence, it further raised public recognition toward the importance of creating environmentally sound communities. This mechanism provides a basis for knowledge development and values of the Okayama Model of ESD, and the support continues until today (**Table 2**).

Second, the media-based & cultural-based public knowledge domain of the QHM version of the Okayama Model of ESD was strongly supported through the establishment of Kominkans. This establishment strengthens the EPP project of ESD by creating a sense of attachment, a sense of belonging between the people and their place, and sensitivity to local issues. Hence, it creates new values systems and social norms from the Okayama Model of ESD as a learning environment for changes that fit into the sociocultural-based domain of QHM (Carayannis and Campbell, 2018). ESD teaches them about the history of the community and place. It gives them more understanding on how to tackle local issues, which shapes the way they interact in the future. Besides, there are community representatives who are involved in the teaching and learning process with the students for the Period of Integrated Studies. The schools allocate a session for the community to get involved in sharing knowledge about their locality (**Table 2**). Moreover, the creation of a conducive learning environment resulting from the effort of the Okayama ESD Promotion Commission creates a cooperative relationship among diverse groups or stakeholders, which includes administrative bodies, citizens' groups and NGOs, and higher educational institutions (Abe and Habu, 2009).

The government's efforts to create an enabling environment help in stimulating the action of the people in the community. It also helps the actors on the co-learning platform for social innovation (Clark et al., 2020; Carayannis et al., 2012, 2017). This explains the interaction between the political and sociocultural media-based domains. Hence, it resulted from the non-linear social innovation form involving various actors beyond the normal education systems (Barth, 2011), that is, Kominkans, residential association, school network, and academia, which requires learning in a collaborative way (König et al., 2020). This also added to the local indigenous practices that represent

TABLE 1 | List of interviewee.

Actor	Position during UN-DESD*	Roles in Okayama ESD project	Current position	Area of interest
A	Environmental Conservation Department → ESD Promotion Division of Okayama City, Commission Member	In the Environmental Conservation Division, Actor A has been looking for ways to solve problems such as pollution with the participation of citizens. In order to promote ESD in collaboration with citizens, he proposed to appoint a full-time coordinator in the city office to connect schools, community centers, local communities and companies. After retirement, his effort goes to revitalize the ESD project with participation of more youth and to create a middle support organization.	Director of Kominkan	Environmental Issues (environmental disruption)
B	Environmental Conservation Department → ESD Promotion Division of Okayama City, Commission Member	Having been involved in the civil society movement for conservation and protection of the environment, Actor B was mainly involved in environmental education in the Department. Since his first encounter with ESD principles, he has been involved in organizing ESD coordinator trainings and internships as a way for people with different interests to meet, exchange, learn and take new actions.	Kominkan Promotion Division of Okayama City	Environmental Preservation (river, biodiversity, outdoor education)
C	Environmental Conservation Department → ESD Promotion Division of Okayama City	Actor C was primarily responsible for promoting ESD to the wider public. She played a central role in developing educational materials to encourage schools to engage in ESD, such as working with university teachers to address the issues of protecting endangered species and managing agricultural waterways, and running workshops to train ESD coordinators to expand ESD initiatives in Kominkans. After 2014, as an ESD coordinator, she worked with the City Board of Education to promote ESD with collaboration among schools, Kominkans and other organizations. She teaches several subjects related to ESD at high schools and universities. She also serves for a private company as their ESD advisor to realize their aim to contribute to create a sustainable local community.	Part-time Lecturer. Manager of the local community café.	Human rights, Peace, Poverty prevention (social inclusion)
D	Environment Counselor. Staff of Non Profit Organization/UNESCO Association. Commission Member	As an expert on the environment and environmental education, Actor D is also deeply involved with a major ESD-leading non-profit organization in Japan. He has been involved in UNESCO activities for many years, and his steady activities have led to the city's membership in RCE and the invitation of the World Conference. He is a leading member of the ESD Promotion Commission and has been involved in human resource development for ESD with Actor A, B, and C since joining the RCE. They have been conducting several projects together such as coordinator training sessions.	Part-time lecturer in addition to the aforementioned positions.	Environmental Issues (water pollution, biodiversity)
E	Chief staff of the Okayama City Central Kominkan	Actor E has been practicing ESD through courses at his community center in preparation for the World Conference on ESD. At the World Conference on ESD, as a representative of Kominkan staff in Okayama City, she has been working with Actor C and D in particular. At the World Conference, as a representative of the community center staff in Okayama, E introduced the concept of ESD in various aspects of managing Kominkan and had a chance to present it. After the World Conference, she has been contributing to the human resource development of ESD as well as the skill development of kominkan staff with C and D. In addition, E has been presenting the ESD activities in Okayama City at workshops and other events throughout Japan from the standpoint of Kominkan staff.	City official at City Board of Education, Human Rights Education Sector	Human rights, Sustainable livelihood, Peace, Parenting
F	Chief staff at K Kominkan	As the chief staff of a Kominkan in the area where ESD is most active in Okayama City, F has organized various courses with Actor D and others, and has been working to improve the existing courses from the perspective of ESD so as to contribute to the creation of a sustainable society. Later, appointed at different Kominkan, she still works on community development from the perspective of ESD while connecting with various local entities. Currently, after retiring, she is working at the Kominkan Promotion Division, making efforts to improve the overall quality of Kominkan in the city with Actor B. She has been presenting good practice of K Kominkan at various opportunities e.g. National meeting of museum educators, which also contributed to spread the idea of improving existing Kominkan courses with the viewpoint of ESD.	Kominkan Promotion Division of Okayama City	Gender, Cross-cultural understanding, Sustainable Livelihood

**UN-DESD: United Nation Decade of Education for Sustainable Development.*

TABLE 2 | Synthesis main finding of Okayama model of ESD from the QHM lens.

Main system of QHM	Main finding	Interview result & validation
i. Environment Preservation Department, Environment Bureau of municipalities of Okayama City – **the Political Sub-system of QHM**	a. **Concern on the local environmental problem.** The department has been dealing with the local environmental related problems, such as river pollution, endangered species, etc. Their main missions were changed into climate change and biological diversity after the Earth Summit in 1992. The city encouraged the Department to motivate and empower citizens as well as companies to raise their awareness and take actions for the natural environment. This initiative was made through a framework titled "Environment Partnership Project: EPP" in 2001. Several local issues were included, such as biotic conservation, waste reduction and natural energy promotion.	Actor D mentioned that he and his colleagues had the opportunity to present the project EPP at the following Earth Summit in 2002, it was well received and contributed to the development of ESD in Okayama City.
	b. **The Okayama City Office's facilitation and initiative** demonstrate the prior initiative in promoting environmental education groups to join the worldwide networks, RCE. The existing form of the 'neighbourhood association' also aids to the transition and knowledge co-creation between QHM's Political and Social-cultural domains.	Actor C described it as follows: *The Environment Preservation Department has been strongly connected with all Kominkans for environment learning and conservation activities (e.g., play education in rivers) which local people should address by themselves (and they also think so). Okayama City supported such activities where local people protect local resources by themselves. It is important.*
	c. **Financial & Technical Support** The facilitation of local government, Okayama City through financial support actualised in an annual budget allocated for ESD projects. Some portion was allocated for each school or citizens group involved in the ESD project. However, the budget is not allocated to Kominkans since they are part of the local government and have their own annual budget allocation.	It is clarified by the following explanation by Actor A. *The Environment Preservation Department made such a system. For example, the city gave brooms and gloves to citizens for frequent cleaning events around the Asahi River or roads in many local areas in Okayama. This became one of the rationales to obtain the approval for RCE. Tens of thousands of people joined the cleaning event. Hence, the fact was highly acclaimed as an ESD activity. The event was not related to Japanese culture. There is the system "neighborhood association" anywhere in Japan where local people support each other, and protect and clean their area together. The local government of Okayama city is closely connected with the associations.*
ii. Media-based & cultural-based public knowledge sub-system of QHM.	a. The Okayama model of ESD is based on the above-mentioned EPP. The Okayama ESD Project started in 2005 had been formulated by combining this successful framework of EPP with the RCE framework made by United Nation University (**Figure 4**). In the Okayama ESD Project, Kominkan came to play a crucial role to realize its ideal framework. Hence, Kominkan become a platform for co-creation knowledge for various key actors executed some part of their ESD Project	Actor A, who focused on the functions and roles that Kominkan can fulfill in advancing the project, recalls as follows; *Kominkan had been established for the first time in Japan under democratic society and a place for people to learn democracy. However, after the Bubble economy period, Kominkan turned to be a cultural center or an enjoyable hobby space as Japan prospered. Since around 2001, the meaning of Kominkan has been questioned nationwide. Okayama City also tried to find out the new way for Kominkan. Kominkan met ESD for the first time in 2005 when Okayama City started working on it.* *The establishment of Kominkan as a community-based learning place for each school district in Okayama city allows the staff to learn about the origins and concept of ESD as the ESD coordinator training sessions conducted by Actor A with advanced knowledge. Accordingly, Kominkan staff considered how to implement ESD and included ESD concepts in their own existing learning projects in the local community. Therefore, Kominkan became a learning platform which is familiar to the local people.* **Actor C**
	b. Okayama city has 37 junior high school districts with one Kominkan, each of which has its own set of regional challenges. The Committee encouraged each school district to start and participate in ESD projects based on problem solving. At that time, school education in Japan was encouraged to address social and regional issues. Accordingly, the Period of Integrated Study was introduced and ESD was indicated to focus on it. The school was looking for a way to do it.	*Kominkan is the core of the community and is a public facility to connect various stakeholders in the community. At Kominkan, people share common awareness and learn from each other in light of social education. It is easier for local residents to gather at Kominkan because it is a public place. I think it is the only place where anyone can come, and people gather together. (The public facility can keep a fairer and more inclusive atmosphere.* ***Actor D***

(Continued)

TABLE 2 | Continued

Main system of QHM	Main finding	Interview result & validation
	c. Kominkan is also a place to learn about history and people of the local community through various learning activities. For example, one Kominkan offers an environmental education class which provides an opportunity for the people to learn the history of the canal/ river running in the community and why it was created in the Edo era. This is how the social-cultural domain links with the Natural Environmental System of the QHM.	*At environmental learning classes at Kominkan, we made an opportunity for them to learn the history/meanings of the canal/river and why they created it in the Edo era.* *The river was necessary for irrigation and transportation of goods by boat between Yoshii River and Asahi River. Now we do not use the river for transportation anymore.* *Once every two months, the Kominkan conducts river water quality research with local residents.* *The Kominkan offers scientific lecture classes for the community people about the numerical standards of the water quality.* *River cleaning was performed by environmental actors and professionals of irrigation from the municipality rather than academic researchers. Because Kurayasu river is designated as a World Heritage Irrigation Structure by the international organization last year, we began to open learning classes about the meanings of the river* (https://www.pixtastock.com/photo/46122159). *Experts from Okayama Fresh Water Fish Research Group also joined to evaluate the water quality by investigating fishes in the river.* ***Actor F***
	d. Local indigenous practices which represent the social-cultural domain of Quintuple Helix shown in local wisdom which carry notable environmental conservation dimensions. Their unique term *Satoyama shows* it. '*Sato'* means hometown village and '*Yama'* means mountains, namely, the word Satoyama represents Japanese people's sense of being a part of nature and living a life in harmony with nature. One of the ESD Projects was conducted by including the Satoyama concept and practices. This initiative shows effort to conserve the Satoyama values to the youngsters as part of the ESD Project.	*The Environment Preservation Department had dealt with Satoyama conservation. Citizens took part in this activity supported by the local government. This Satoyama project was not recognized as a part of ESD originally, but it was associated with environmental conservation projects since nobody had not been aware of ESD around that time.* *Okayama City connected the Satoyama project with ESD and made a presentation on it as an ESD project at COP10.* ***Actor C***
iii. Education System	a. **Strong collaboration between Schools and University.** The connection between and within the domain recorded the knowledge transfer among the sub-system of QHM. Collaboration between schools and universities has been well observed since the early stage of the project. Further, the platform includes commissions and municipalities of Okayama City where sharing information and activities occurs through exchange of opinions beyond school districts, working fields or groups as part of the Okayama ESD project.	Actor C, who experienced the very beginning of introducing ESD and its confusion, remembered the moment to have finally grasped the meaning of ESD. This episode tells the important essence of knowledge transfer from different domains at different levels. ***Actor C*** reflected that she had not realized the meaning of preserving specific endangered species as an official and citizen-led project until she learned the integration of the concept of ESD toward creating a sustainable society. She recalls as follows: *"This frog has shorter back legs and cannot jump high enough to escape out of concrete walls surrounding a paddy field. But without the concrete walls a long time ago, the frogs could go anywhere without problems. As a result, they have been crushed by bulldozers and endangered.* *I understood that Okayama City tried not to conserve the endangered frogs but to maintain the environment where everyone including such creatures and humans with difficulties can live together".* After this learning moment, she has been actively playing a role to nurture "ESD Coordinator" in collaboration with other leaders including Kominkan chief staff. The establishment of Kominkan as a community-based learning place for each school district in Okayama city allows the staff to learn about the origins and concept of ESD at the ESD coordinator training sessions conducted by these actors with advanced knowledge. Accordingly, Kominkan staff considered how to implement ESD and included ESD concepts in their own existing learning projects in the local community. Therefore, Kominkan became a learning platform which is familiar to the local people.
	b. **Transformative Learning.** There were meaningful evidence captures for transformative learning happening through the ESD project. A professor from Okayama University, together with Kominkan, civic groups, the local government is also involved in the Takashima Elementary School to support their ESD project as a part of the Satoyama project. The project connected various groups/people beyond the boundaries of their fields. In the context of ESD in urban areas, the Satoyama project means to learn about how to select the future through conservation of endangered species.	

(Continued)

TABLE 2 | Continued

Main system of QHM	Main finding	Interview result & validation
	c. Involvement in RCE Global Network Involvement RCE Okayama in the global RCE network adopted the RCE framework. The framework involves formal education networks such as school education and non-formal education such as neighborhood association, Kominkan and etc which also demonstrate the shift toward community-based projects. On the other hand, the Kominkans had been also exploring how they can work with schools for the betterment of the local community. The needs of the both educational institutions were integrated with the support of the city while they were promoting ESD at various levels.	***Actor B*** recalls that the participation process of RCE functioned as establishing more co-learning relationships between various stakeholders. The pillar services of the committee were "to give subsidies for activities to those groups without a sound financial basis, to give training/learning opportunities for leaders of the groups, to enlighten people on ESD/SD, and to hold exchange events among people to further their cooperation" according to **Actor B**.
	d. The ESD Promotion Commission of Okayama City holds clear educational missions to develop people's capacity required for ESD. The commission is a part of the political domain of QHM which encouraged and registered various existing organizations to participate in the project. Their main discussion contest was how to nurture leaders and how to specifically do these pillar services. Kominkan and the city board of education are also a chief member of the Commission. Hence, there is clear interaction between the Political System and Education and Media-Cultural Based System.	
	e. Strong Knowledge Culture Knowledge exchange captured in various directions such as the involvement of academia from Okayama University demonstrated in several ESD Projects, having activity in Kominkan and being involved in the ESD Promotion Commission.	*There are many roles. For example, one of the professors in Okayama University was like a coordinator to organize people's opinions. Another professor from a different college with many foreign students had these students involved in local community programs that he proposed. I expect that such a system will expand with connecting university lectures/teachers and community activities.* ***Actor D***
	f. Strong ESD implementation ESD has been seen as a movement for societal learning as part of transforming society where the knowledge integration among the actors of QHM is crucial. It leads to knowledge convergence which plays a crucial role by the existence of the ESD Promotion Commission. Future Okayama model of ESD is highly dependent on the connection among the actors/domains which allows knowledge sharing among them for co-creation sustainability. There are some expectations to look at the unified and integrated programs for the children.	*ESD has been getting mainstreamed here in Okayama, and it has developed to be the ESD project through ESD Promotion Commission, not just Environmental Partnership Project, therefore there are many academia involved now.* ***Actor D***
iv. The Natural Environment System	Mainstreaming the natural environment conservation is still the main concern in Okayama Model of ESD contributing by each sub-system. This domain is strengthened by strict standard regulation which contributes to the overall environmental performance of Okayama. Thereafter, Kominkan and schools started ESD activities and most of them are focusing on environmental issues.	Actors B and C also explained how they made it possible to start the project city-wide, based at Kominkans. *Kominkan gathered people on both sides to make discussions for mutual-understanding. We tried to change people's awareness and they discussed making local preservation standards and rules to live without hardships together with endangered creatures. Each of the community should make/have their own local preservation standards and rules on what to be protected and how much to protect them.* ***Actor B***

the sociocultural domain of the quintuple helix model shown in local wisdom that has a strong environmental dimension such as *satoyama* (woodlands).

Third, the QHM education system version of the Okayama Model of ESD is explained by several characteristics: (i). strong collaboration between schools and universities, (ii). transformative learning, (iii). involvement in the RCE global network; (iv). the ESD Promotion Commission of Okayama City, (v). strong knowledge culture, and (vi). strong ESD implementation (**Table 2**). The connection between and within

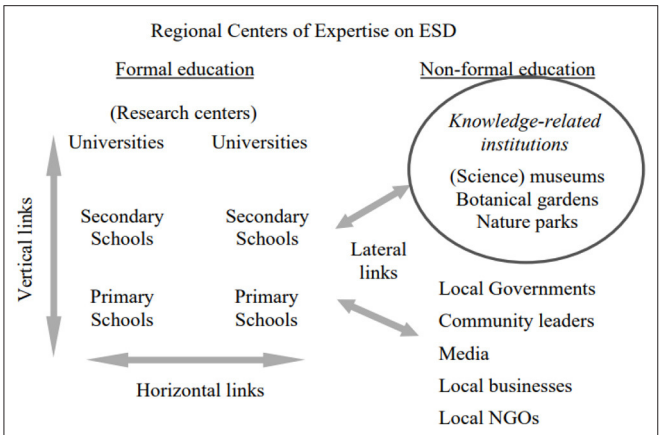

FIGURE 4 | Standard RCE framework and the actors, and the source is UNU (2004).

the domains recorded the knowledge transfer among the entities of the system of QHM.

Fourth, the QHM natural environment system version of the Okayama Model of ESD is characterized by the main concern in conserving natural environment resources (**Table 3**). This is where the landscape of Okayama City becomes the living lab for any ESD project involving community, school children, and local authorities.

Based on interviews with relevant officers, it was found out that the ESD Promotion Commission expanded the ESD to the local communities by providing training about the RCE concepts. This effort was coupled with the provision of a coordinator, who is essential to encourage people to join the project and connect with other organizations to promote ESD activities. The ESD Promotion Commission/Division is funded at the City's expense and is a part of Okayama City Hall. **Figure 5** summarizes the chronological sequence of ESD in Okayama.

Fifth, the economic subsystem of the Okayama Model of ESD is demonstrated by the involvement of an architect firm in the ESD cafe (**Table 3**). The president of an architect firm who participated in the ESD café organized by the Okayama ESD Promotion Commission learned about ESD, consulted with the ESD coordinator, and transformed his company building into an ESD learning center in collaboration with both schools and Kominkans, and began to implement a number of sustainability practices. Specifically, in one area of Okayama City, schools, community centers, and private companies and civic organizations have been working together to build a sustainable society. The results of these efforts have been found in the proactive participation of a large number of children and youth in activities, their growth as "middle leaders" in the area's disaster prevention planning, and the sharing of awareness among local residents. Above all, it is evidenced by the fact that the problematic delinquent behavior of children in the area, which was thought to be caused by the rapid development of the area and the fragmentation among the residents, has improved, and the area is now one of the most popular and prosperous areas for migration among the citizens.

It is worth mentioning that the company has been reflecting the philosophy of sustainability in real estate sales, construction, and urban development; this has raised the interest of the general public in the region toward a sustainable society. In cooperation with the local government, they have established a group consisting of various stakeholders including neighborhood associations, schools, Kominkans, and other local actors/businesses to create a park that can function as a disaster prevention base in the community through dialogues among citizens. It has also linked the junior high school's Period of Integrated Studies to this movement, turning it into an activity in which many citizens participate. At the park, other economic activities such as small businesses, agriculture and food sales based on sustainability, and NPOs that promote *satoyama* development have started to gather; and a small community of practice for creating a sustainable society has begun to form (Okayama ESD Promotion Commission, 2020).

Another school district in the south of the city, which has been involved in ESD for the longest time, is an area developed by land reclamation and is facing the issue of large-scale agriculture and its management; the elementary school, which is an ASPnet School, is particularly enthusiastic about ESD activities in cooperation with local farmers, university teachers, and students. However, in such a region, an industrial waste disposal company was often perceived as a nuisance. After participating in an ESD coordinator training session organized by the Commission, the company decided to transform itself into an environmentally creative company that would be accepted by the local community. The company has since joined the Okayama ESD project, welcomed the actors to the company, conducted ESD workshops for employees, held lectures at local elementary schools, created environmental education programs, and conducted environmental tours in cooperation with community centers. In Japan, industrial waste management is still often associated with antisocial forces, and there has been a tacit understanding that it is impossible to run a company like this with clear accounting and a break with these forces. However, it is worth mentioning that the company has changed this situation and created an industrial waste business that contributes to the improvement of the local environment (Chugoku ESD Center., 2022).

DISCUSSION

The Okayama Model of ESD is considered as part of a long-term societal change that was originally based on the Social Education Act launched in the 1940s. Social education is known as *Shakaikyôiku*, the Japanese word for non-formal education. It is defined by the Social Education Act, Article 2 as *the areas of adult education, community education, and education for children and youth that take place outside of school*. The overall learning ecosystem of the model is also supported by the local government's establishment of social education infrastructure, financial and technical support, and facilities. The certified social education manager as a module developed by Okayama University with the supervision of

TABLE 3 | Quintuple helix model, QHM analysis of Okayama model of ESD for transformation.

QHM framework of Okayama model of ESD	Key actor	Social eco-innovation system of QHM OM-ESD	Knowledge co-creation and values	Societal transformation
1. Political sub-system/domain	Environment preservation department, environment bureau of municipalities of Okayama city Kominkan neighborhood association. school network academia	i. The establishment of Social Education Act 1946 Promotes lifelong learning for the Japanese in general. This act stimulated the non-formal education of community involvement in activity related to the conservation effort of EPP. Hence, conserve their environment. They plan/implement social education activities in the regions and are in charge of providing specialized technical advice and guidance to those engaged in social education. (Social Education Act, Article 9-3) ii. Established "Environment Partnership Project: EPP" in 2001 to empower citizens and it still continues until today. iii. The enactment of the Law for the Promotion of Nature Restoration 2002 provides a framework for nature restoration projects implemented through the participation of various local projects. iv. Establishment of the steering board consists of representatives of research institutions, citizen's groups and administrative institutions. v. Okayama Promotion Commission connects/network people as part of RCE Okayama, global RCE network. vi. Financial support to fund ESD Project promotes school network and neighborhood association coupled with technical and knowledge support. vii. The local government facilitates the environmental education groups to join the global network of RCE. viii. Establishment of Kominkan/ community learning center, CLCs as an extended arm of local government for social education.	i. Promotes lifelong learning which allows the exchange of tacit and scientific knowledge. ii. For example, local issues such as biotic conservation for endangered fish species, Ayumodori, illegal waste and natural energy promotion. iii. Strengthen the knowledge exchange through various programs such as the local government teach out to neighborhood associations (socio-cultural system) encourage them to actively participate in preserving the endangered species and conservation activities in their region, the Natural Environment sub-system of QHM. iv. The steering board becomes a platform for knowledge exchange and consensus building among actors/ stakeholders. v. Establish a platform to strengthen the network of actors and knowledge sharing. vi. Facilitate the knowledge exchange and value creation. vii. Adoption RCE framework of action provides a platform for knowledge exchange beyond formal education. This includes the knowledge transfer in Kominkan, external sources of knowledge such as Museum, local library and public parks. viii. Provide program, class and course, such as Improvement the level of Cultivation (Hobbies, Artistic pursuits), Home education/Home economics, Improvement of professionals' knowledge and skills and public spirit/Spirit of social solidarity	i. The institutional policy change that stimulates societal transformational change. ii. The institution/ local government initiatives that reach out to society provide a basis for societal changes. iii. Gives the trust for community work on local restoration projects which stimulate socio-ecological changes. iv. The institutional organizational change. v. The institutional organizational change. vi. The implementation of ESD Project helps to promote sustainable development and create transformational changes to the local organization and the society. vii. The involvement in RCE global network promotes supra governance on sustainability. Hence, contribute to societal transformation.
2. Education Sub-System	i. School Network – ASPNet School – for formal education Okayama University through formal education provides training for social educators. Kominkan for non-formal education	i. School as a source of formal education utilizes natural environment landscapes such as public park, rivers as a source of learning. ii. Co-creation social educator program for certified training by Okayama University with a collaboration with the Ministry of Education, Sports, Science and Technology (MEXT). iii. The creation of class, course and program in Kominkan as a source of non-formal education through training, education awareness, public talk, etc. iv. The inclusion of in-formal and non-formal education as part of the formal education by the establishment of Social Education Act 1946. Hence, acknowledge the other source of knowledge such as museums, libraries and the natural landscape such as public parks, rivers and river basins etc. v. Social Education Coordinators (Directors) Outline (Social Education Act, Article 2, 9-2). Specialist staff of social education who are	i. The new knowledge creation through interaction with nature as a new learning experience. This interaction gives them a chance to apply knowledge from the classroom into the real case experience. This also created the new values of appreciation to nature. ii. Specific knowledge creation to develop modules for Social Education Managers. iii. Applied knowledge for lifelong learning skills to strengthen the social aspect and wellbeing of the people is part of the community development effort of Kominkan. iv. Convergence of knowledge for educated and civilized society which creates unique values in society.	i. Student's interaction with nature gives them experiences for a transformative learning experience. ii. Continuous individual capacity building as a constant effort that contributes to societal transformation. iii. The institutional policy change that stimulates societal transformational changes. iv. Continuous improvement of individual capacity with a high participatory method.

(Continued)

TABLE 3 | Continued

QHM framework of Okayama model of ESD	Key actor	Social eco-innovation system of QHM OM-ESD	Knowledge co-creation and values	Societal transformation
		required to be placed in the respective Boards of education of prefectures and municipalities {cities and towns/villages with a population of over 10,000) prescribed by the Social Education Act. vi. Social Education Act, Article 9.4 (1) University training course Attendance of universities for two years or more, acquirement of 62 credits or more, completion of university training course (24 credits over 4 courses) and 1 year of work experience (2) Training course Attendance of universities for two years or more, acquirement of 62 credits or more, completion of Social Education Coordinator training course (9 credits over 4 courses) and 3 years of work experience		
3. Media-socio-cultural Sub-System	i. Kominkan ii. Neighbourhood Association iii. NGOs iv. NPOs	i. Function to promote community development with a community facility. The viewpoint of nationalism, social education was considered as a tool to deal with social problems. ii. Neighbourhood associations (socio-cultural system) execute ESD Project under supervision of Environment Department, Kominkan or Community Learning Center, CLC. iii. ESD Project include risk society in which disaster, poverty and lack of childcare etc. have become big issues, social education which was supported by the welfare country, is also placed in an unstable situation. iv. ESD Café and ESD Week become a platform for knowledge exchange and where the people interact. v. Kyoyama ESD/SDGs festival once a year.	i. Promotes social education and lifelong learning that emphasize on welfare and social wellbeing and overcome social problems in the society. ii. Social education and cultural activities. iii. Various ESD Project becomes a platform for experiential learning and to educate the community, the school children, the local government officers and academia interact. This where a transdisciplinary approach happened by includes scientific and tacit knowledge and inspired action through experiential learning. iv. Engagement sessions to share knowledge and to instill new values that practice annually provide a platform for community of practices where the knowledge sharing happens (CoP).	i. Networks and relationships strengthened networks, sharing with networks, development of social capital. ii. Networks and relationships expand and strengthen and become the foundation for transformation and development of social capital. iii. The ESD café and project become a source for transformation of the society where dialogue and interaction between community representatives, NPOs and NGOs happen. It becomes the source for co-learning. iv. The festival becomes part of the Okayama community's practices.
4. Natural Environment Sub-System	i. Natural landscape of Okayama City/ prefecture ii. Public Parks iii. River / river basin iv. Endangered species	i. Endangered species and conservation activities, waste reduction and natural energy promotion and awareness. ii. Establish initiative to overcome the Japanese agricultural modernization impact such as loss of wetlands, habitat fragmentation, and contamination. iii. The natural environment through a framework titled "Environment Partnership Project: EPP is a project-based approach that tackles specific local issues by involving school children, community / Kominkan and local government.	i. Establish local tacit knowledge in addressing local issues. ii. Promotes the aspect of Japanese agricultural methods as a source of learning, creating practical knowledge of know-how that contribute to values creation.	Individual capacity and continuous participation of social learning in the context of socio-ecological transformation. Ecological crisis that triggered the societal changes happened through the execution of the ESD Project. Socio-ecological transformation and institutional changes through ESD Project that contributes to sustainability transition with societal transformation.
5. Economic Sub-System	The Architect firm The neighbourhood association NPOs ASPnet schools Okayama University.	i. Create an industrial waste disposal plant as a place for environmental learning. ii. Aims to achieve a recycling rate of 100% by separating and transforming building-related industrial waste into recycled products (#73 *"Industrial Waste Disposal Plant as a Place for Environmental Learning - Fuji Clean Co., Ltd."*|, *ESD Relay Column List	Our Action	Water and Greenery To Achieve SDGs Oyama ESD Nabi (okayama-tbox.jp)*	i. Establish further research and development of recycling technology. ii. Create a creative learning platform to develop a recycling-oriented society. iii. Creating a practical knowledge of recycling know-how that contributes to value creation in the society.	i. Establish link with the ASPSchool network, neighborhood and the University for continuous individual capacity transformation and institutional changes.

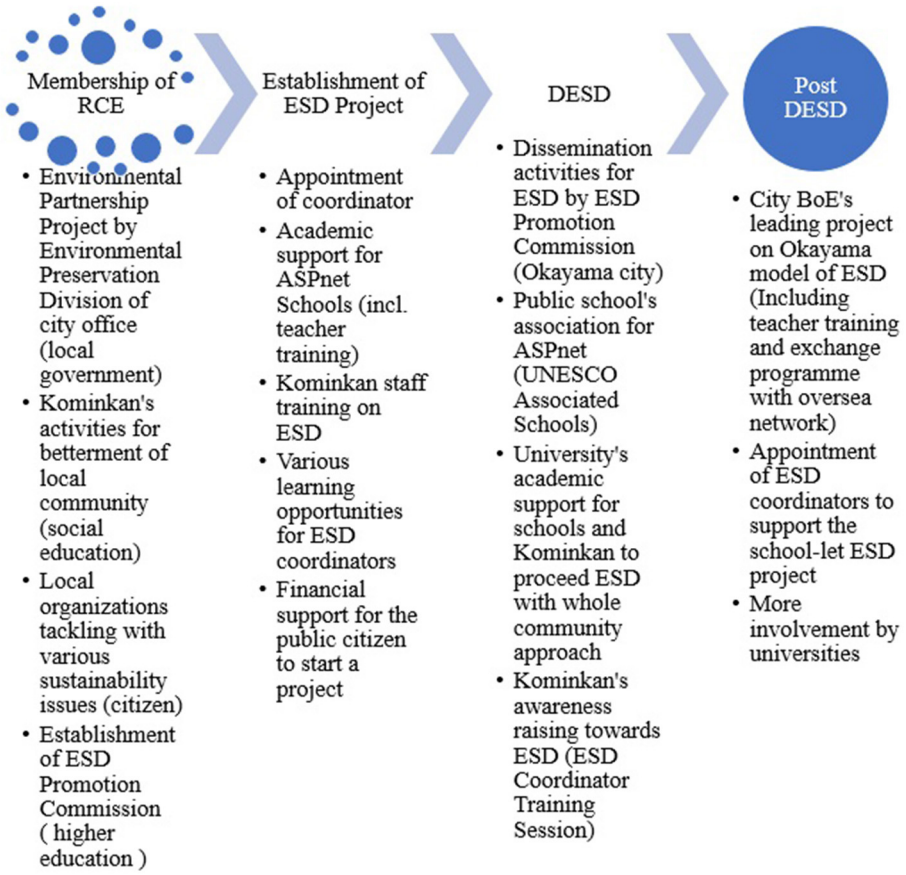

FIGURE 5 | The chronological sequence of Okayama ESD.

MEXT is a form of investment or "*input*" in QHM to produce highly skilled human resources in managing Kominkans and any other social learning activity as an *output* (MEXT, 2006). Further, it contributes to sustainable governance and strong institutional support (Ostrom, 1990), and serves as an example for collective action of the socio-ecological system (Anderies et al., 2004) from the EPP/ ESD project. This forms the institutional/organizational changes that contribute to the overall transformation of the society (**Table 3**). It demonstrates how society overcomes challenges posed by sustainability transition experiments beyond sustainability projects, that is, the ESD project (Williams and Robinson, 2020). This study shows how social learning through knowledge circulation in Kominkans speeds up the transition process, as mentioned by Schäpke et al. (2017). It encourages social change and social innovation, that is, social educator training, which contribute to long-term societal transformation as summarized in **Figure 6**.

As a regional center for lifelong learning, Kominkans in Okayama City offer a variety of courses and classes for self-realization and cultural and personal interest-based learning such as music, painting, cooking, and dance. The Okayama Model of ESD has focused on the potential of Kominkans and has made full use of their functions. As a result, Kominkans have come to play a major role in the promotion of ESD as knowledge hubs. By facilitating social learning, this approach becomes an example of a sustainable transition experiment within a government organization (Williams and Robinson, 2020). Through active knowledge clusters and innovation networks, it has become a platform for democratizing knowledge in Okayama City through knowledge circulation. This coexisted with the QHM's sociocultural domain, which had a strong non-formal educational realm of ESD dating back to its social education legislation in the 1940s. Kominkans serve as a meeting place for the actors of the education system, such as academia, students, and the sociocultural subsystem, by offering a space for people to learn about knowledge and gain certain skills linked to their culture (**Figure 6**). As a result, Kominkans and continuous training serve as a framework for consistent community participation and the formation of ESD Communities of Practice (**Table 3**).

Japan's MEXT promoted the establishment of Kominkans across the country and ratified the social education function as a similar concept with non-formal education. Kominkans are legalized social education facilities, according to the outline of the Social Education Act, Articles 20, 21, and 23. Following World War II, local governments frequently built Kominkans

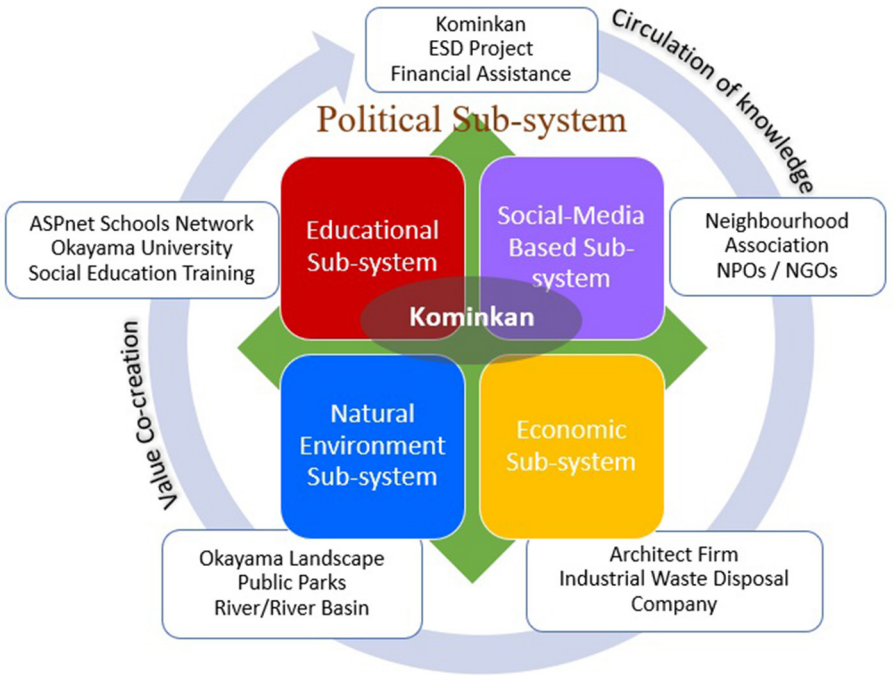

FIGURE 6 | Quintuple helix model version of the Okayama model of ESD.

for local inhabitants in compliance with the Social Education Act. Kominkan's mission is to conduct various projects for the cause of education, science, and culture, meeting the daily needs of residents in municipalities and other specific areas to develop their attainments, improve their health, cultivate their sentiment, elevate their cultural life, and increase the community's social welfare. The Minister establishes the standards required for the establishment and operation of Kominkans to promote their sound development.

As social education has a strong connection with Kominkans, it is further defined as all formal, non-formal, or informal education that promotes social development and societal progress (Wang, 2019). In this part, the role of adult education including children and youth non-school education in the community and family was reinstated (Matsuda et al., 2016). Later on, it became citizen-led initiatives where the origin of technical terms of science instilled social values and strengthened the local knowledge and community (Calabrese Barton, 2012). Hence, the Okayama Model of ESD becomes an inspiring example of community-based ESD for effective social learning to facilitate social change (Didham et al., 2017; Wals et al., 2017) with the involvement of citizen science (Calabrese Barton, 2012) driven for the ESD project.

In the context of QHM, the Okayama Model of ESD implements the non-linear innovation model where various types of information are gathered involving various actors beyond the formal education system (Grundel and Dahlström, 2016; Provenzano et al., 2016; Franc and Karadžija, 2019; Durán-Romero et al., 2020). Several initiatives such as Kominkans, ESD projects, social education, and RCE involvement contribute to the transdisciplinarity of the Okayama Model of ESD. This demonstrates the strong intervention of political subsystems into other types of subsystems. Domination of the political subsystem of the Okayama Model of ESD highlights several core points, which are described in **Figure 6** and explained below:

- ***The Governance of the ESD initiative*** - Starting the ESD project with full commitment of Okayama City smooths the knowledge executed in various communities' projects that involve various modes and levels of education: formal, non-formal, and informal education. The involvement of the local government staff as the executive board of the Okayama UNESCO Association in 1994 in the series of Earth Environmental Lecture of UNESCO educational programs led to ESD activities (Okayama ESD Promotion Committee 2015). The governance of the ESD initiative shows the existence of the Okayama ESD Promotion Commission, which is represented by research institutions, citizen's groups, educational institutions, corporate enterprises, administrative institutions, and media organizations.
- ***Robust Framework of Knowledge Exchange*** - The adoption of the RCE knowledge framework (RCE Okayama (Okayama ESD Promotion Commision Secretariat)., 2011) as being part of the involvement of RCE Okayama in the RCE global network was initiated by the municipality of Okayama City (**Figure 4**). It provides vertical and horizontal knowledge interaction among the education entities. This allows a more diverse knowledge exchange, robust results on the

application of the ESD project, and smooth knowledge circulation among key actors. This framework provides a knowledge co-creation platform with other actors or domains of the Okayama Model of ESD. The horizontal knowledge interaction links where each of the school entities has their own knowledge sharing on ESD project within their students. Non-formal education, categorized as social education, involves "Specialized Institutions," which include art museums, Kominkans, science museums, libraries, botanical gardens, and natural parks. Meanwhile, the possible vertical knowledge among the government, civic communities, and enterprises involves the local government, local education authorities, local UNESCO association, NPOs/NGOs, private enterprises, and mass media. The existence of RCE Okayama with its RCE global framework provides a solid foundation to support social education in Okayama (**Table 2**). Moreover, being part of the RCE global network, which has around 200 members from various countries, provides a supra learning experience at the global scale by emphasizing local action and facilitates value creation (Mochizuki and Fadeeva, 2008). This is the only platform that connects the local community for local action with global concern or the GloCal approach. It is one of the most effective long-term ways to achieve social transformation, increase environmental awareness, and facilitate the economic de-growth transition (Glavič, 2020).

- ***Transdisciplinary Knowledge Exchange*** - The RCE framework of action establishes a transdisciplinary system in which citizens with tacit knowledge are participating in environmental activities. Citizen participation is visible through civic clubs, neighborhood associations, and Kominkans in every community. All of this contributes to the formation of a robust network of social systems and the creation of sustainable resource governance in the context of Ostrom's institutional analysis framework (1990). RCE Okayama's active participation in developing the annual ESD Okayama Award for excellent community-based ESD projects demonstrates their dedication to educating greater society within the RCE network declared by Okayama City (ESD Okayama Award, 2021). Furthermore, the Okayama Environmental Cooperation Project, which is a citizens–local government partnership for ESD projects such as cleaning the river and rescuing endangered species, demonstrates the construction of a conducive atmosphere that stimulates society's voluntary and spontaneous activity. This work highlights how the strong citizen science movement (Calabrese Barton, 2012) contributes to the wellbeing of Okayama society and characterizes the model.
- ***Values Creation Through a Network of Actors*** - While a detailed assessment of a sustainable society based on value generation examines value creation from philosophical, ethical, economic, psychological, and technical perspectives, with a focus on society's decision-making dilemma (Ueda et al., 2009), our findings emphasize the creation of social mechanisms for value creation through a network of actors, the existence of a Kominkan as a regular meeting place, the ESD Cafe, and regular ESD training and support. The community-driven ESD initiative launched by the government or political system and reaching out to the societal domain through the Okayama ESD project exhibits significant civil society support in sync with other systems.
- ***Training the Social Actor*** - The Social Education Manager's course is offered by the QHM education system, such as in Okayama University. As a response to the stipulations of Articles 9-5 of the Social Education Law, the political domain of QHM, it is co-organized by MEXT and the Faculty of Education, Okayama University. This link strengthens knowledge generation for social innovation. The goal is to govern activities like social education manager training, so that individuals who should be social education managers have the particular knowledge and abilities required to carry out their activities. The course covers a wide range of topics such as lifelong learning theory; lifelong learning society in the framework of social education; collaboration among schools, families, and communities and learning systems I and II; and the significance and function of social education administration.
- ***Conserving Endangered Species*** - The natural environmental domain is evidenced by local environmental changes and the Okayama City Council's concern. Actor A's second interview, Interview No. 2, captured this. This scenario can be explained in terms of Japanese agricultural modernization, which has resulted in the loss of wetlands, habitat fragmentation, and contamination of the environment (Naito et al., 2012). As a result of wetland loss, rice paddies and neighboring regions have played an important role in providing substitute habitats for wetland species and supporting the diversity of indigenous ecosystems. Resultantly, the Okayama City Council's Environmental Preservation Division prioritized the preservation of these species. The new agriculture policy in Okayama prefecture's suburban area acknowledged that both patch- and landscape-scale factors can influence pond frog distribution (Yamamoto and Senga, 2012).
- ***Activities at School for the Local Environment*** - The Okayama City Council-funded ESD project forges an intriguing link with the QHM education system. Their Division of Environment Conservation has taken the lead in involving the school in the preservation of several endangered local species. The ASPnet school students, for example, investigated how to reintroduce the endangered wild bellied newt Cynopspyrrhogastersp to their river ecosystem, feeding them once more. The school nurtures the nature conservation character of its students from an early age by connecting them with their local environment. This initiative establishes a solid foundation for future generations to care for their natural environment, particularly in the Okayama region. This initiative exemplifies the link between education and the natural environment system as part of the socio-ecological transition that occurred in the Okayama Model of ESD. This is an example of one of the schoolchildren's conservation initiatives to rescue endangered local wildlife.
- ***Strong Local Network*** - By connecting networks, for example, encouraging environmental education groups to join this network, the development of the ESD ethos, as described by Abe as a "whole-city" approach, is accelerated. For instance,

ESD Promotion Committee members in the most advanced districts have emphasized from the beginning that ESD is important for building a sustainable society, and that collaboration between local residents and the government is essential for this (Usami, 2017). Despite the concern to protect and maintain endangered species and the environment, network connectivity and work accelerates the application and dissemination of the ESD spirit in the Okayama community. This phrase defined Okayama's sustainable society. The council developed the "Okayama ESD Project Fundamental Plan" and launched the "Okayama ESD Project" (Okayama Promotion Commission 2014). This discusses the co-creation of knowledge and values in Okayama.

The natural landscape of Okayama City includes public parks, rivers, and river basins; and endangered species conservation. This initiative provides a platform for ongoing individual capacity development and social learning involvement in the context of socio-ecological transition. The Okayama ecological catastrophe prompted societal transformations through the implementation of the ESD project. For example, an initiative was launched to combat the effects of Japanese agricultural modernization, such as the loss of wetlands, habitat fragmentation, and contamination. As a result, socio-ecological transformation and institutional changes are achieved through the ESD project, which contributes to a sustainable transition with societal transformation. This link contributes to the building of local tacit knowledge in addressing local concerns and promotes the natural environment as a living learning lab, a source of learning, and a source of practical knowledge that contributes to the production of values. Accordingly, the natural environment is being protected using a framework known as "Environment Partnership Project: EPP is a project-based strategy that addresses specific local challenges by involving school children, community/Kominkans, and local government" (Okayama ESD Promotion Commission, 2014).

There are several essential points that connect the Okayama Model of ESD in QHM:

(i) The implementation of the ESD project funded by Okayama City Council functions as a unified entity that synergizes several systems in QHM (**Figure 6**). Within the educational system, the university is involved in sharing knowledge through lectures and training, community projects involving students and community, and Kominkans. This interaction smooths the co-creation knowledge of Mode 3 or the transdisciplinarity where tacit and scientific knowledge meets (Mauser et al., 2013). Kominkans function as a platform for non-formal education—a social place to nurture the Japanese culture and values, and various talks and programs related to community such as healthy lifestyle, healthy food, and arts and crafts. Presently, since ESD is mainstreamed now in Okayama, the university acts as a leading body of ESD and the additional role of academics at Kominkans is as a coordinator to organize people's opinions and get students involved in local community programs. There are also students ESD-related credits of courses on human resource development from taking part in community/ESD activities. This system expands the university lectures/teacher's connection with community activities (Gardner et al., 2021). The university's community involvement through lecturing relates with the local social issues. Consistency of this effort until today creates a network of society that learns about their local issues.

(ii) Kominkans' social and information system serves as a connector for various stakeholders such as NGOs, NPOs, residential associations, and school networks in the community, and brings people together. Hence, it smooths the knowledge circulation that contextualizes each locality. Kominkans' professional staff, that is, the social education manager is also essential for the accomplishment of self-governing Kominkan operations that necessitate certification. The Kominkan employees, who are elected by local citizens and represent them, may not be qualified, but they are the most knowledgeable about their town. As a result, the element of tacit knowledge and local spirit shows the "Shimoina Guiding Principles." According to this philosophy, they serve as professional practitioners who work with and for local residents and have a thorough awareness of their requirements.

(iii) Okayama City's nomination as a UNESCO Key Partner of the Global Action Programme on ESD (GAP) to accelerate sustainable solutions at the local level exemplifies the Okayama Model of ESD's knowledge co-production for a sustainable society. This collaborative effort has long been established in Kominkans through community-based learning, which promotes community development, social welfare, and active participation of all community members (Murata and Yamaguchi, 2010); and through the "three-levels" building theory of Kominkans, also known as People's University, which promotes inclusive education and lifelong learning to the Japanese (Kajita and Yamamoto, 1992; Ogawa, 2005). This initiative reinforces Japanese cultural values and social norms. This establishes the foundation for strong tacit knowledge for a transdisciplinary approach and lifelong learning. The establishment of RCE Okayama in 2005, which has a broad knowledge platform from the participation of various actors, has also contributed to this. The earlier establishment of RCE aims to improve ESD around the world and has been successful in supporting the Okayama Model of ESD. The involvement of diverse participants in RCE aims to create new forums for debate and collaboration across numerous organizations and groups in Okayama, including educational institutions, municipal administrations, and civil society, laying the groundwork for social innovation. Resultantly, it appears to be a hybrid autonomous government that promotes innovation (Champenois and Etzkowitz, 2017).

Well-established knowledge circulation through the ESD project and subsystem attracted the local architect firm. This is where knowledge circulation is spreading to the economic subsystem

by the active involvement of the local government in education and social education at public platforms like Kominkans. It can also be said that the innovation starts from the encounter and resonance between small individuals, such as an ESD coordinator and a company president, which was also indicated by the transformative learning theory as transformation always occurs in encounters with other perspectives. However, these businesses are still at the nascent stage, and it is necessary to take a long-term look at how much influence they have on the transformation of the local community into a sustainable society.

CONCLUSION

Through the lens of QHM, this study investigated the theoretical underpinnings and innovative rationales for the Okayama Model of ESD. The previously developed strong social learning culture gives a solid platform for the subsystem and actor to engage. As a result, a Mode 3 transdisciplinary environment is fostered in which each actor's contributions are recognized. The study reveals several practices that other societies in other regions can emulate, with an emphasis on transforming the learning and training environment, developing the capacity of social educators, and providing training for social managers in Kominkans; and provides a platform for social learning for every citizen and various actors to meet, mobilizing youth through the school network and ESD project, and accelerating sustainable solutions at the local level. This QHM lens reveals that the remarkable function of non-formal education in Kominkans outperforms formal education in Okayama. It is because of its power in allowing many vital domains to connect that QHM as an analytical framework captures how diverse stakeholders and a network of participants defined as *all learners* interact to acquire knowledge and skills as part of an eco-innovation ecosystem to promote sustainable development. Resultantly, it contributes to the socio-transformational development of the Okayama people, which historically has the intention to promote democracy and human rights as well as lifelong learning. The spirit of knowledge sharing and working collaboratively align with the spirit needed to achieve sustainable development and combat climate change.

The following results were reached as a result of this study: (i). The QHM analysis is capable of clarifying the process involved in the Okayama Model of ESD as a non-linear circulation of knowledge as a result of the involvement of various modes of education and communities of practice approaches in Kominkans and the ESD project; (ii). The creation of a conducive knowledge circulation environment with the system's contribution for knowledge co-creation and generation contributes to the co-creation of values and the overall transformation of society; (iii). Okayama has adopted the RCE global framework, which provides a platform for the manifestation of various actors' inter- and transdisciplinary approaches; (iv). Improving actor performance as a knowledge producer and a knowledge user toward knowledge democratization, which is critical in the society's eco-societal transition; and (v). The QHM analysis of the Okayama Model of ESD aids in strengthening the knowledge-based society for eco-innovation in inter- and transdisciplinary approaches.

Over a longer time period where social learning has been in place since the establishment of the social education act in the 1940s, it has contributed to the development of the sustainable society of Okayama, which is referred to as the Okayama Model of ESD.

Even though the study captures the enabling environment that facilitates knowledge co-creation across subsystems, it is unable to document the type of knowledge generated due to the project's short time frame and limited travel permits to Okayama, Japan due to the COVID-19 pandemic.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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