Blue Bonds for Marine Ecosystem Sustainability

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Abstract. This study comprehensively analyzes the transformative role of blue bonds as an innovative financing instrument designed to address crucial funding gaps in marine ecosystem conservation and restoration efforts. Against the backdrop of a global environmental crisis exacerbated by climate change, plastic pollution, and overexploitation of fisheries, there is an urgent need for funding mechanisms that are not only effective but also transparent and sustainable. Blue bonds, which are a sub-category of green bonds, offer strategic solutions by mobilizing capital from the global bond market and allocating it exclusively to projects that contribute to the development of the blue economy. This research outlines the conceptual framework of blue bonds, reviews the success of global case studies such as the Republic of Seychelles and specifically explores opportunities and challenges in their implementation in archipelagic countries such as Indonesia. Through this analysis, this study aims to provide clear policy guidance to advance the marine sustainability agenda and contribute to the achievement of the targets of the Sustainable Development Goals (SDGs) 14 and the national vision of a golden Indonesia by 2045.

Keywords: Blue Bond, Ocean Sustainability, Marine Ecosystems, Blue Finance, Blue Economy.

1 Introduction

1.1 Critical Conditions of the Global Ocean Economy and the Urgency of Action

Marine ecosystems have an important role as climate regulators and essential service providers that support global survival and well-being. More than 70% of the Earth's surface is covered by oceans, which play a vital role in regulating the climate, producing oxygen, and providing invaluable natural resources [1]. However, in recent decades, marine ecosystems have experienced significant damage due to massive anthropogenic pressures. Reports from various international organizations show that the threat to the ocean has become an urgent global crisis.

One of the biggest threats is climate change which causes changes in seawater temperature and ocean acidification. Rising temperatures are triggering mass coral bleaching, which threatens coral reefs that are one of the most biodiverse ecosystems in the world [2]. Meanwhile, the excess absorption of carbon dioxide by the ocean will alter the pH of the water, which harms marine organisms with calcium carbonate shells,

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such as shellfish and corals. Another threat that is also at risk is plastic pollution. An estimated 11 million metric tons of plastic enter the ocean each year, damaging habitats and endangering marine life. The economic impact of plastic pollution is also significant, with global losses reaching USD 450 million per year for the marine sector [3].

In addition, unsustainable fishing practices, such as illegal, unreported and unregulated fishing (IUU Fishing), have led to a drastic decline in global fish stocks. The FAO (The State of World Fisheries and Aquaculture 2020) report reveals that 34.2% of the world's fisheries are overexploited [4]. As a result, the food security of coastal communities that depend on fisheries is threatened, and the balance of marine ecosystems is disturbed. This condition demands a coordinated and planned global response with adequate allocation of resources for mitigation and adaptation.

1.2 Funding Gap and Innovative Financing Needs

Although the threat to the ocean is widely known, conservation and restoration efforts are often hampered by large funding gaps [5]. The funding available from government budgets and philanthropic institutions is insufficient to meet the large-scale needs to protect and manage marine ecosystems effectively. Most conservation projects, coral reef restoration, and fisheries management initiatives require long-term investments that are not attractive to traditional private capital. This gap creates serious obstacles in achieving the Sustainable Development Goals (SDGs), especially 14 (Life Below Water) which aims to conserve and use marine resources sustainably [6].

Surveys and reports from various financial institutions show that there is a need for billions of dollars in annual funding to finance the transition to a sustainable ocean economy. This gap cannot be closed without the involvement of the private sector. Therefore, innovative financial instruments are needed that can bridge the gap between funding needs and the availability of private capital. This instrument must be able to attract investors who are looking for financial returns as well as positive environmental and social impacts.

1.3 The Birth of the Blue Economy as a Paradigm of Sustainable Development

Realizing that marine protection cannot be separated from economic development, the concept of the blue economy emerged as a new paradigm. In contrast to traditional marine economies that focus on resource extraction without considering sustainability, blue economies emphasize the efficient and environmentally friendly utilization of marine resources. Gunter Pauli, in his book The Blue Economy, proposes a business model that mimics how natural ecosystems work, where waste from one process becomes an input for another process [7].

Prisip – blue economy principles include innovation, waste minimization, circularity, and long-term sustainability. This approach allows traditional maritime sectors such as fisheries, shipping, and tourism to transform into more environmentally friendly, while opening up new sectors such as marine renewable energy and marine

biotechnology [8]. Thus, the blue economy becomes a strategic framework that integrates environmental protection with economic growth, creating jobs and creating people's well-being.

1.4 Blue bonds as an Innovative Financing Solution

In the context of urgent financing needs and a growing blue economy framework, blue bonds are emerging as one of the most promising financial instruments. As a sub-category of green bonds, blue bonds specifically raise capital for projects that contribute to ocean and water sustainability. The mechanism is simple: The issuer, whether a government, a financial institution, or a corporation, issues bonds to investors. Proceeds from the sale of bonds are allocated to finance or refinance projects that meet stringent marine sustainability criteria [9].

Examples of projects that can be funded by blue bonds are diverse, ranging from the construction of offshore wind power plants, the development of sustainable fisheries and aquaculture, to plastic waste management and coral reef conservation initiatives. The uniqueness of blue bonds lies in their transparency and accountability. Investors can track how their funds are used, and issuers are required to report the environmental impact of funded projects. This is of interest to institutional investors and individuals who increasingly prioritize socially and environmentally responsible investments (ESG Investing). The historic issuance of blue bonds by the Republic of Sychelles in 2018, with the support of the World Bank, demonstrates the feasibility of this instrument for countries that are heavily dependent on marine resources. The $15 million bond successfully funded the transition from capture fisheries to sustainable fisheries and expanded marine protected areas, proving that capital markets can be a powerful partner in marine conservation [10].

1.5 Indonesia's central role and the urgency of the implementation of Blue Bonds

For Indonesia, an archipelagic country with more than 17,000 islands, the ocean is not only a natural resource, but also a national identity and an economic driving force. With a very abundant marine biodiversity. Including being at the end of the coral reef triangle, Indonesia has a great responsibility and opportunity to lead in global ocean conservation. Indonesia's Golden Vision 2045 places maritime economic development as one of the main pillars, with a maritime contribution target of 12.5% to GDP [11]. However, Indonesia also faces major challenges, including marine pollution, unsustainable fisheries, and degradation of coastal ecosystems. To achieve its 2045 vision and SDGs targets, Indonesia needs consistent large-scale investment. The government has shown commitment by issuing SDG bonds and a blue financing framework, but funding challenges remain. Therefore, the implementation of blue bonds in Indonesia has a very high urgency. This instrument can be a catalyst to attract private capital both from within and outside the country, to finance projects that not

only protect the environment but also promote sustainable and inclusive economic growth.

2 Literature Review

2.1 Blue Economy Concept and Blue Financing

The concept of the blue economy has come a long way since it was first introduced. This term was first popularized by Gunten Pauli in 2010 through his book The Blue Economy, 10 Years, 100 Innovations, 100 Million Jobs [7]. Pauli proposed an economic model that mimics natural systems, where waste from one process becomes a valuable input to another, creating a non-waste cycle. Since then this concept has been adopted by various international institutions and governments as a framework for sustainable development.

Organizations such as the World Bank, the United Nations, and the OECD define a blue economy as the sustainable utilization of marine resources for economic growth, improved livelihoods, and the health of marine ecosystems. This is in contrast to the traditional "marine economy," which often focuses on the exploitation of marine resources without considering the long-term environmental impact. The core principles of the blue economy can be classified into three main pillars, namely: First, environmental sustainability that emphasizes the protection of marine ecosystems, wise resource management, and mitigation of environmental impacts from economic activities. This includes coral reef conservation, mangrove forest protection and efforts to reduce marine pollution. Second, social inclusivity, ensuring that the benefits of maritime economic development are enjoyed equally by all levels of society, especially vulnerable coastal communities. The goal is to improve the welfare of traditional fishermen, create decent jobs, and promote gender equality in the sector. The third is economic innovation, encouraging the development of new technologies and business models that are more environmentally friendly and efficient. Examples are the development of marine renewable energy sources, marine biotechnology, and technology-based fisheries to increase yields while minimizing environmental impact [8].

Blue financing is a key component of the blue economy. It is a term that encompasses a wide range of financial instruments designed to support the transition to a sustainable marine economy. The need for blue finance arises due to the large funding gap between the investment needs to reach SGD 14 and the resources available from the public sector and philanthropy. Blue finance aims to bridge this gap by attracting private capital through specially structured instruments. Examples of these instruments include blue loans, blue bonds, blue carbon credits, and equity investments in companies oriented towards marine sustainability. World Bank identifies blue bonds as the most promising instrument in terms of market scale and potential [3].

2.2 The Role of Blue Bonds in Marine Conservation: Case Studies and Mechanisms

Blue bonds are thematic bonds whose issued funds are exclusively allocated to finance or refinance projects that have positive environmental benefits for the ocean. The mechanism follows similar standards to green bonds, but with a special focus on maritime projects. The principle of green bonds issued by the International Capital Market Association (ICMA) is often used as a reference, adjusting for the marine context. A credible blue bond framework has four main components, namely the use of funds, the project evaluation and selection process, fund management, and reporting.

The issuance of the world's first blue bonds by the Republic of Seychelles in 2018 was an important milestone. With a population of less than 100,000 people, Seychelles' economy is heavily dependent on the tourism and fisheries sectors. The issuance of bonds worth USD 15 million is supported by the world bank and the Global Environment Facility (GEF). The funds raised are allocated to support the expansion of Seychelles' marine protected areas to 30% of their total Exclusive Economic Zone (EEZ) area and improve sustainable fisheries management, including providing soft loans for fishermen to purchase environmentally friendly equipment [10].

The success of this project shows that blue bonds are not just a financial instrument, but also a strategic tool to achieve national conservation goals. After Seychelles, countries such as Fiji also issue blue bonds to finance climate resilience and conservation projects. In addition to the government, multilateral institutions such as Nordic investment banks and the corporate sector have also started issuing blue bonds to fund projects such as clean water management and cleaner shipping [12].

2.3 Implementation of Blue Bonds in Indonesia: Opportunities and Challenges

As the largest maritime country in the world, Indonesia has a unique potential and urgency to implement blue bonds. With two-thirds of the area being water, Indonesia has 15% of the world's total coral reefs and 3.2 million hectares of mangrove forests, which are essential ecosystems for biodiversity and coastal protection. In addition, the fisheries and marine tourism sectors are important pillars of the national economy, which absorbs millions of workers [13].

The Indonesian government has shown a strong commitment to the blue economy. The Ministry of National Development Planning (Bappenas), in collaboration with the World Bank, has prepared a roadmap for Indonesia's blue economy [11]. This roadmap identifies five priority sectors for blue economy development, namely fisheries, renewable energy, tourism, marine biotechnology, and maritime services. This framework provides a strong foundation for the identification of projects that are eligible for funding through blue bonds. However, there are several challenges that must be overcome to be able to implement blue bonds effectively in Indonesia.

First, the lack of a clear legal and policy framework. Despite the commitment, the legal framework for blue bonds still needs to be developed. Clear standards and guidelines are needed to ensure transparency and accountability, which are key to

attracting international investors. Second, the limited capacity and technical capacity to design, manage, and report projects that meet the criteria for blue bonds are still limited. Investment in training and development of human resources at the government and private levels is needed. Third, the availability of 'bankabel' projects to attract investors, projects that not only have a positive impact on the environment, but are also financially feasible. Sectors such as small-scale capture fisheries may find it difficult to meet these criteria without additional support.

Nonetheless, the chances are huge. The investment potential for maritime projects in Indonesia is huge, ranging from the development of plastic waste management infrastructure in coastal cities, the development of sustainable fisheries cultivation, to the development of wind and wave energy in remote areas. With an increasingly aware investor population of sustainability issues, blue bonds can be an effective bridge to flow capital from the global market to crucial projects in Indonesia, encouraging the achievement of Indonesia's 2045 gold target and SDG 14 simultaneously [14].

3 Methodology

This study uses a qualitative approach with a literature study method. This approach was chosen because the focus of the research is to analyze the concepts, roles, and challenges of blue bonds which are relatively new financial instruments. Literature studies allow researchers to collect, evaluate, and synthesize secondary data from a variety of credible sources to build a comprehensive source. The data sources used in this study are, scientific junal and academic publications, official reports of international institutions, policy publications, and case studies.

The data analysis method used is content analysis. Data collected from various sources were analyzed to identify key themes, patterns, and causal relationships between the concept of blue bonds and their potential impact on the sustainability of marine ecosystems. This analysis is descriptive and interpretive, aiming to provide a clear picture of how blue bonds can be used as a strategic tool for sustainable development in Indonesia. The study selection process is summarised in Fig. 1 (PRISMA flow diagram).

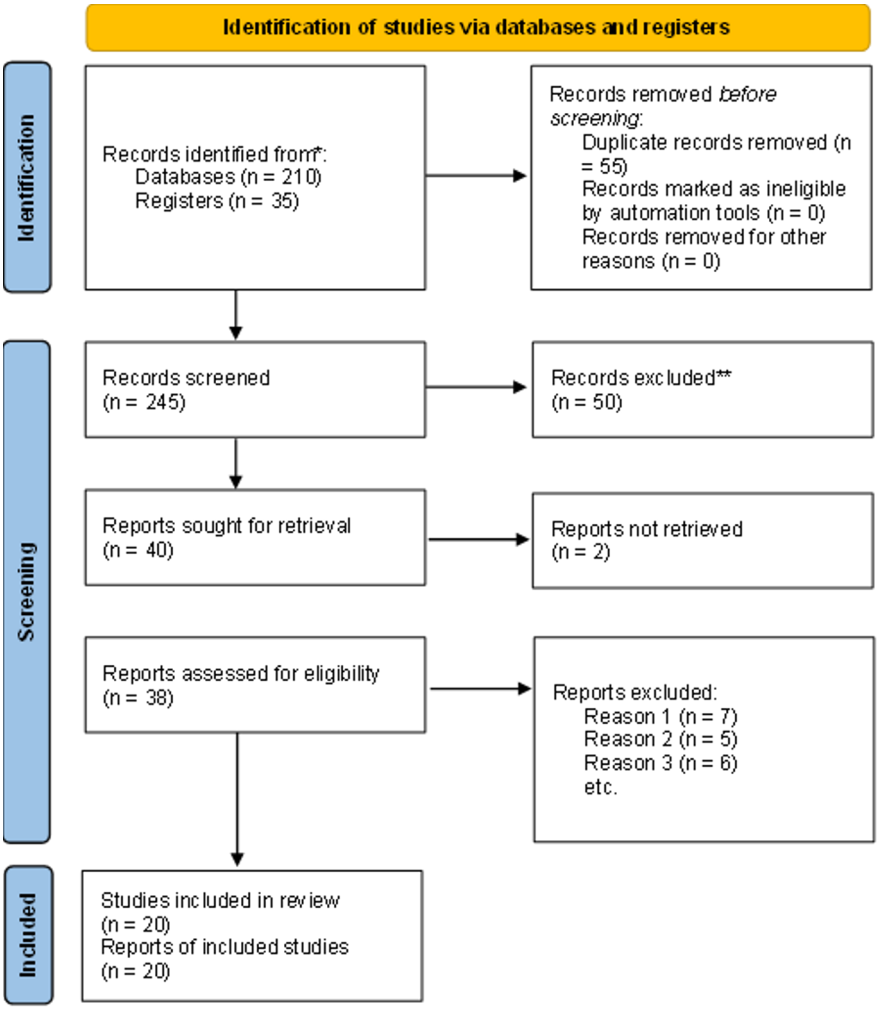

Fig. 1. PRISMA flow diagram of study selection

4 Results

4.1 Implementation and Digital Skill Levels of Employees

The Department of Population and Civil Registration of Parepare City has fully adopted digital technology, implementing various integrated information systems such as SIAK Terpusat, Benroll, and Bcard to optimize public services. Nevertheless, this study found a disparity in digital skill levels among employees. This gap is particularly evident among senior staff, who showed lower digital proficiency and a lack of motivation to learn. This finding is supported by an informant's statement: “There are some

employees who are about to retire, so they find it difficult to operate the applications. Based on age, they also don't really want to learn, thinking 'I'm about to retire' and are less motivated due to age factors...”

4.2 Digital Skill Development Strategy

This study found that the Department of Population and Civil Registration of Parepare City implemented two primary approaches to developing its employees' digital skills: formal and informal.

Formal Development. This method includes technical training, technical guidance (Bimtek), and seminars. Bimtek is the most frequently used method to introduce updates to the SIAK system. However, budget constraints pose a significant challenge, as expressed by one informant: “There is a budget for human resource development, participating in Bimtek when there are new applications or regulations. The Directorate General often provides Bimtek.” To address this limitation, the Department of Population and Civil Registration of Parepare City implemented a “train the trainer” system, where employees who participate in training are responsible for sharing knowledge with their colleagues.

Informal Development. Beyond formal training, employees also actively engage in independent or self-taught learning to master the necessary applications. This is a very dominant and practical solution for them. One informant explained: “Most of my friends are self-taught, those who understand IT use their skills to produce results. They have to know all the materials and procedures or procedures for using the application, there's no training.” This approach is achieved through the use of information technology such as media platforms (YouTube and Google) or peer-to-peer learning, with the consideration of cost efficiency, as another informant explained: “Everything is self-taught through Google because if you want to create an application, it's expensive. Why would we participate when we can make it cheap, useful, and economical?”

4.3 Digital Innovation and Its Impact on Performance Improvement

The digital skills possessed by employees at the Department of Population and Civil Registration of Parepare City have proven to extend beyond routine operations, significantly contributing to the development of digital innovations that directly enhance the quality of public services and organizational performance. These innovations provide clear evidence that the development of digital skills is positively correlated with improved performance. Some of the notable innovations developed include Mappadeceng, a service utilizing social media platforms (WhatsApp, Email, Facebook) and websites to facilitate public access to population administration document issuance; Zaskia (Strategy for Children to Get Child Identity Cards Immediately), a service that enables the public to upload required documents via WhatsApp; and Lapor Hati (Birth and Death Event Reporting Service), a collaboration

with health institutions allowing for the reporting of vital events through a dedicated application on the Department's website.

These developments demonstrate the employees' ability to effectively apply new knowledge and ideas to problem-solve, ultimately improving work effectiveness in the field of population administration.

4.4 The Key Role of Leadership and Infrastructure Support

The successful implementation of the digital strategy at the Department of Population and Civil Registration of Parepare City is inseparable from the crucial role of leadership, specifically the Head of the Office, who functions as a digital leader. Leadership, in this instance, does not merely provide instructions but actively engages in operations and innovation, setting a direct example for the staff. This is corroborated by the testimony of an informant, who stated: “He leads by example. He doesn't just talk, he sets the example. For example, if he comes in person on Sunday, it would be uncomfortable for us employees to just order things around. It's easy, but the leader sets the example, so we feel uncomfortable.” Furthermore, the findings indicate that adequate infrastructure support, such as providing closed internet access for internal use and open access for the public, is a crucial prerequisite for success. However, the study also identified significant challenges in the form of frequent internet network disruptions and power outages that hamper smooth service delivery.

5 Discussion

5.1 Implementation and Digital Skill Levels of Employees

This finding indicates that the success of e-government implementation in the public sector depends not only on the availability of technology but also on the capability of the human resources who utilize it. The adoption of digital systems in Parepare aligns with the view of Agafonova et al. [18], who assert that the public sector needs to adapt to digital innovation to carry out its mission. Furthermore, this supports Fan's [20] argument regarding the need for an optimal and proactive HRM strategy to accelerate digital transformation.

Despite this, the skill gap revealed in this study represents a significant challenge. The lack of motivation linked to age factors demonstrates that internal barriers, not just external ones, can impede the success of transformation. This finding underscores the importance of digital skills as a vital factor in enhancing performance and internal task execution, consistent with the views of Štofková et al. [16] and Ujwary-Gil and Godlewska-Dzioboń [17]. Academically, this lack of motivation can be analyzed through the HRM literature that emphasizes the importance of employee commitment, fostered through SHRM practices [3], [7]. Therefore, these findings imply that an effective HRM strategy must go beyond providing technical tools and training and also proactively address the behavioral and motivational challenges of employees to ensure the maximum adoption and utilization of technology.

5.2 Digital Skill Development Strategy

This finding illustrates the comprehensive approach of the Civil Registration Office in addressing skills demands in the digital era. The formal strategies implemented, such as technical guidance, align with the views of Haque and Nishat [14], who stated that digitized HR practices, such as e-training, have a direct impact on employee performance. This approach reflects the organization's commitment to facilitating continuous learning and professional development, as emphasized by Fokina et al. [10].

Nevertheless, the most significant finding was the dominance of informal approaches, which indicates budgetary constraints and personal initiative among employees. The statement that "there is no training" for certain applications confirms that informal development is a pragmatic solution under these circumstances. This aligns with research by Nurhasanah and Sinambela [13], who stated that digital HRM encourages efficient collaboration and communication, which indirectly supports digital skill development through knowledge sharing among colleagues. Furthermore, the "train the trainer" model implemented was a highly effective strategic adaptation. This practice not only addressed resource constraints but also created a culture of knowledge sharing, which in turn enhanced collective capabilities.

Overall, this combination of formal and informal strategies demonstrates that the Department of Population and Civil Registration of Parepare City has integrated digital skills development as an integral part of its HRM framework. This aligns with the findings of Kambur and Yıldırım [12], who showed that adopting digital technology in HRM can significantly improve individual and organizational performance, albeit with a pragmatic approach tailored to the realities of the field.

5.3 Digital Innovation and Its Impact on Performance Improvement

The findings strongly support the literature linking HR strategy to organizational performance through the maturation of digital capabilities. Innovations such as Mappadeceng, Zaskia, and Lapor Hati are not just technical adjustments; they are tangible representations of the dynamic capabilities generated by a skilled workforce. This is consistent with the view of Kareem and Mijbas [6], who assert that integrating dynamic capabilities into HR development initiatives can enhance organizational effectiveness. Furthermore, these findings reinforce Zhang's [4] argument that effective HR practices—specifically digital skills development in this context—positively impact organizational performance by nurturing employee capabilities. The employees' ability to leverage familiar platforms like WhatsApp to create efficient services demonstrates how information technology integration, as emphasized by Mirzayi and Motaghi [5], can serve as a catalyst for improved performance. Overall, these digital innovations confirm the tangible impact of investing in digital skills development. Their adoption and implementation have increased service efficiency and effectiveness, aligning with Kambur and Yıldırım's [12] finding that digital technology adoption in HRM can significantly improve individual and overall organizational performance. These results demonstrate that employee digital skills are a strategic asset that not only

supports operations but also triggers innovation that drives substantial performance improvements in the public sector.

5.4 The Key Role of Leadership and Infrastructure Support

These findings highlight two external factors essential to the success of digital transformation in the public sector: strategic leadership and supporting infrastructure. Leadership that leads by example aligns with the views of Azzukhruf et al. [7], who explored how strategic HRM practices and committed leadership indirectly foster employee commitment to organizational goals. This leadership approach also reflects efforts to create a competitive advantage, as expressed by Kosasih [1], by cultivating an environment where employees feel supported and encouraged to develop their digital competencies. Meanwhile, the availability of infrastructure, such as internet access, is a fundamental foundation of any digital HRM initiative. This supports the views of Mirzayi and Motaghi [5], who underscore the value of information technology integration as a catalyst for employee development. The provision of internet access at the Department of Population and Civil Registration of Parepare City represents a concrete implementation of this practice, enabling employees to carry out increasingly technology-dependent tasks. Conversely, findings regarding infrastructure challenges like network disruptions and power outages indicate that physical barriers can significantly hamper the effectiveness of otherwise ideal digital HRM practices. Although Noor [23] explains the importance of transformation to digital HR, this finding adds that unstable infrastructure readiness can be a major obstacle preventing the achievement of optimal work effectiveness and productivity.

6 Conclusion

The global economic ocean crisis demands an integrated response between environmental conservation and economic development. As an innovative financing instrument, blue bonds emerged as a solution to bridge the funding gap that has been hampering marine sustainability efforts. Through targeted and transparent allocations and actions, these bonds not only mobilize private capital for marine projects that have a positive impact but also drive accountability and environmental performance reporting.

Global case studies such as those conducted by the Republic of Seychelles, prove that blue bonds are an effective and viable tool, even for economically vulnerable countries. For Indonesia, with its maritime potential and urgent environmental challenges, blue bonds are more than just a financial instrument, they are a key strategy to realize the vision of a golden Indonesia 2045. By developing a strong policy framework, building technical capacity and identifying financially viable projects, Indonesia can take the lead in blue financing, ensuring that economic growth goes hand in hand with protecting marine ecosystems for future generations.

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