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Reframing scarcity through social thermodynamics and Islamic ethics: An interdisciplinary conceptual approach

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Abstract: This metatheoretical study emerges from a critical reassessment of classical economic thought, which reduces scarcity to a mere technical issue of limited resources against unlimited wants—neglecting its deeper social, ecological, and ethical dimensions. In the face of accelerating global crises marked by structural inequality, institutional decay, and environmental degradation, scarcity is better understood as a manifestation of rising social entropy—a systemic disintegration triggered by the depletion of social energy such as trust, participation, and moral legitimacy. This research aims to reframe scarcity through an interdisciplinary synthesis of social entropy theory (Bailey), social thermodynamics modeling (Tsekov), and foundational Islamic ethical principles including *'adl* (justice), *amanah* (trust), and *mīzān* (cosmic balance). Using a conceptual literature review, this study develops a theoretical framework that positions ethical and spiritual values as vital forms of social energy capable of counteracting entropy and sustaining systemic equilibrium. The findings reveal that scarcity is not simply a material deficiency but a multidimensional crisis demanding a transformative response—one rooted not only in technical rationality but also in spiritual wisdom, distributive justice, and collective moral responsibility. The study contributes a novel conceptual model that bridges physical social science with Islamic moral epistemology, offering a holistic lens for understanding scarcity while informing equitable public policy, institutional reform, and sustainable social design.

Keywords: distributive justice; Islamic ethics; multidimensional crisis; scarcity; social entropy

Introduction

Entering the 21st century, the global community is faced with increasingly complex multidimensional crises, ranging from climate change, resource scarcity, geopolitical conflicts, to increasing social fragmentation and political instability (Scheffran, 2025). These phenomena not only create ecological and economic pressures, but also expose institutional failures and widening social gaps, both in developed and developing countries. In this context, the discourse on scarcity has undergone a significant redefinition, shifting from a classical understanding that focuses on physical limitations to a broader structural and systemic understanding (Sen, 2014). Scarcity is now understood not only as a quantitative absence of resources but as a condition that arises from institutional dysfunction, distribution inequality, and entrenched power asymmetry (L. Robbins, 1932).

The traditional view of economics formulated by (P. Robbins, 2019) views economics as "the science that studies human behavior as the relationship between a rare end and means that have an alternative use." Although this definition provides analytical clarity, it is mechanistic and tends to ignore the normative and ethical dimensions of the production process and the experience of scarcity in society. As criticized by (Sen, 2014), scarcity often does not come from insufficient production, but from the failure of the distribution system, inequity of access, and weak institutional rights.

In today's global situation—where millions of people in different parts of the world are experiencing a lack of clean water, energy, food, and access to education or health services—conventional economic approaches are increasingly perceived as inadequate to understand the root of the problem thoroughly (Mishra, 2023). In developing countries, especially in the Global South, scarcity is often exacerbated by neoliberal economic policies, weak governance, and dependence on unequal global market structures (L. Mehta et al., 2019).

Indonesia, as a large archipelagic country with a population of more than 270 million people, faces complex social and economic challenges that are highly relevant to be understood in the context of social entropy and structural inequality (Soseco, 2021). Despite experiencing significant economic growth over the past few decades, the distribution of benefits has not been evenly distributed, which is reflected in the Gini coefficient, which is consistently in the range of 0.38 to 0.41 (World Bank, 2023). This inequality is further exacerbated by the striking geographical gap between the western and eastern regions of Indonesia, such as the persistent poverty in Papua and Nusa Tenggara, compared to economic centers such as Jakarta and Surabaya (Rosidin, 2021).

This phenomenon can be analyzed through a framework of social thermodynamics that looks at the uneven redistribution of economic energy—in the form of resources, access, and opportunities—as a trigger for increased social entropy (Tsekov, 2023a). The centralized and asymmetrical flow of resources leads to systemic imbalances that lead to social fragmentation, unrest, and a decline in trust in state institutions (K. D. Bailey, 1990). In addition, environmental degradation due to deforestation and unsustainable development practices such as oil palm expansion has worsened social and economic conditions, especially in the Kalimantan and Sumatra regions (Resosudarmo & others, 2019).

Weaknesses in governance, as reflected in Indonesia's ranking in the Corruption Perception Index (Transparency International, 2023), further intensify the conditions of social disorder and weaken the control mechanisms needed to maintain stability. However, Indonesia also has strong social capital through socio-religious frameworks, especially Islamic teachings that emphasize justice (*'adl*), *amanah*, and *ukhūwah*, as well as the ideology of Pancasila which is the normative foundation for social unity and justice (Ananta et al., 2021).

Therefore, an interdisciplinary approach is important to examine scarcity as a systemic phenomenon. Contributions from sociology, ecology, and philosophy have broadened our understanding of scarcity as part of complex systems. (K. D. Bailey, 1990) introduced the concept of *social entropy* to describe the increasing dysfunction in social systems, with reference to the second law of thermodynamics in physics. In this view, the social system, like the physical system, has a tendency towards systemic disorder or destruction if there is no intervention capable of restoring balance.

Social entropy indicates a gradual degradation of social coherence, such as weakening of public trust, increasing inequality, and declining institutional legitimacy. (Schneider & Kay, 1994) state that the dysfunction is not just random, but reflects a structural failure when society is unable to adapt to change. Within this framework, scarcity emerges as a symptom of a deeper systemic failure.

The contribution of contemporary thought, such as that developed by (Tsekov, 2023a) further enriches this approach. Through the *minimalist model of social thermodynamics*, Tsekov views society as an open system that continues to evolve, where entropy will continue to increase unless it is balanced with *social energy* inputs in the form of innovation, value reform, public participation, and ethical governance. In the model, variables such as freedom, economic mobility, and social engagement are important elements in maintaining a systemic balance (Mulgan, 2019).

Tsekov's ideas are in line with approaches in complexity science and systems theory that emphasize the importance of adaptive capacity in maintaining the sustainability of the social order (Meadows et al., 2004). Thus, scarcity cannot be understood solely as a matter of physical availability, but as the result of an interaction between institutional dysfunction, social exclusion, and ecological damage (L. Mehta et al., 2019). In an increasingly interconnected and volatile world, understanding scarcity as a systemic phenomenon is becoming increasingly urgent.

In this landscape of thought, it is important to situate Islamic thought on scarcity as an autonomous and comparable epistemic framework, not merely as a complement to the modern paradigm. The Islamic intellectual tradition offers a deep understanding of the interconnectedness between humans, resources, and morality (Sarif & Ismail, 2025). Principles such as *'adl* (justice),

amanah (belief), *maslahah* (public good), and *mīzān* (cosmic balance) form the philosophical and theological foundations that interpret scarcity not as a purely technical problem, but as a consequence of spiritual failure, overexploitation, and systemic inequality (Rahman, 1980).

Institutions such as *zakat*, *waqf*, and *infaq* in Islam are designed not only as a distribution mechanism, but also as structural corrective tools to maintain social justice and prevent the accumulation of wealth that undermines the order (Juhro et al., 2025). In this framework, scarcity is not a natural inevitability, but a deviation from the value system that is supposed to maintain a balance between individual rights, social responsibility, and natural sustainability (Randall, 2021). This perspective also offers a normative critique of the global economic system that is exploitative and obscures the ethical dimension in resource management.

Thus, this article offers a framework of social thermodynamics as a theoretical approach that combines the laws of physics, sociological insights, and ethical values—both from the modern scientific tradition and the Islamic tradition. This approach aims to examine scarcity as a multidimensional phenomenon that involves the interaction between institutional inefficiency, social dysfunction, moral degradation, and spiritual crisis. Instead of viewing scarcity as a mere technical problem, this approach sees it as a complex symptom of a social system that has lost its moral direction and structural balance. Within this framework, the dialogue between modern science and Islamic treasures has become very relevant to formulate a more just and dignified model of development and sustainability.

Literature Review

Social Thermodynamics and Islamic Perspectives in Understanding Scarcity

The concept of social thermodynamics has its roots in interdisciplinary efforts to understand social dynamics through analogy with the principles of physics, specifically thermodynamics and entropy (Westbroek et al., 2020). This approach seeks to explain how social systems—like physical systems—undergo structural degradation (entropy) when there is not enough energy input to maintain its equilibrium. In the social context, "energy" is not only material inputs, but also includes innovation, inclusive governance, public morality, and institutional legitimacy. (Castellano et al., 2009) underline how statistical physics can model patterns of behavior in complex societies, especially through the dynamics of opinion and social network interactions. Their findings suggest that collective phenomena such as conformity, polarization, or information dispersion can be modeled similarly to particles in physical systems, thereby providing predictive capabilities for social responses in the context of systemic stress. (Tsekov, 2023a) further develops this approach through a minimalist model of social thermodynamics that includes three main elements: human (social subject), economy (means of production and distribution), and entropy (degree of disorder). Using van der Waals' equations—which are commonly used to explain phase transitions in physics—Tsekov showed that social systems are subject to the second law of thermodynamics, in which social entropy increases naturally in the absence of external input. In this context, social energies (such as trust, solidarity, and innovation) serve to maintain stability and prevent the collapse of social structures (Tsekov, 2023b).

More than three decades earlier, (K. D. Bailey, 1990) had introduced the concept of social entropy as a framework for understanding the disintegration of institutions and societies. It divides entropy into three categories: global (which reflects total systemic dysfunction), changeable (which still allows for improvement through policy), and irreversible (which leads to the total collapse of the social structure). Increased entropy, according to Bailey, leads to social fragmentation, loss of collective cohesion, and delegitimization of public institutions. Therefore, entropy reduction strategies require structural adaptation and revitalization of social values. (Mitar, 2010) and more recently (Labanca et al., 2020) show that although thermodynamic metaphors provide powerful insights into explaining systemic failure, the greatest challenge lies in quantifying social variables such as "moral energy" or "institutional legitimacy". Although it does not have the experimental precision of the exact science, it is still useful for explaining the causal relationship between moral dysfunction and systemic inequality.

The integration of physics, sociology, and economics provides a broader conceptual framework for seeing scarcity not just as a result of a lack of resources, but as a symptom of a systemic

crisis, both from a distributional, ethical, and institutional aspect. This is in line with the criticism of (Sen, 2014), who states that scarcity often arises from entitlement failure, not from absolute scarcity. In this case, distribution and access become more important than the amount of resources themselves.

Furthermore, this approach reinforces an Islamic perspective that emphasizes distributive justice, social responsibility (*mas'uliyyah*), and trust (*amanah*) as the basis for the sustainability of social systems. Islamic economic thought sees that when the distribution of wealth is unfair, zakat and waqf function as corrective social energy that can restore systemic balance (Siddiqi, 2004). Moreover, the principle of mīzān or cosmic equilibrium taught in the Qur'an reflects the spiritual analogy of the law of entropy: if the system is not kept in harmony, then destruction becomes inevitable (Rahman, 1980). Recent research by (Walker & Walker, 2020) in the journal of Ecological Economics reinforces this argument by showing that strong ethical and institutional values have a significant correlation with declining social entropy in the context of developing countries. They assert that social sustainability depends on a combination of ethical governance, community participation, and a value system that binds society morally.

The combination of Bailey's theory and Tsekov's model provides a foundation for understanding social systems as open systems that require continuous renewal in values, structures, and social relations. When these inputs stop or diverge, entropy increases, and scarcity manifests as a crisis not only economic, but existential and spiritual. Therefore, understanding scarcity in this context must take into account moral and institutional dynamics, not just technical and material (Ghezzi et al., 2025).

Scarcity, Social Entropy, and Structural Transformation

The theoretical framework of this research is built on the assumption that scarcity cannot be adequately understood through classical economic approaches alone. In (P. Robbins, 2019)'s view, scarcity refers to a condition in which limited resources must be allocated to meet unlimited needs—a definition that has dominated economic thought for nearly a century. However, this definition is too reductionist, as it frames scarcity only as a quantitative problem, ignoring the social, political, and ethical context of resource allocation (Rahim & Omar, 2012).

Amartya Sen emphasized that scarcity is often caused by uneven distribution mechanisms, not just the absence of goods. Thus, a normative approach to scarcity is essential to understand systemic contemporary crises (Sen, 2014). Scarcity, in this view, is not a neutral condition but one produced by a system that perpetuates inequality. This framework integrates perspectives from Islamic political and economic ecology, which emphasizes distributive justice and responsibility for creation (Zaman, 2018).

In this study, scarcity is conceptualized as an indicator of social disorganization or increasing entropy in society. Thus, social entropy becomes a key concept that allows the integration of thermodynamic logic with criticism of social structures. Originally developed in thermodynamics to measure disturbances in physical systems, the concept of entropy has been adopted across disciplines including ecology, information theory, and social theory (Nielsen et al., 2020).

In the social context, (K. D. Bailey, 1990) introduced the idea of social entropy to explain how social systems rise in chaos when institutions fail to perform regulatory functions. Social entropy reflects a loss of cohesion, a decline in value structure, and a weakening of distribution mechanisms in society. When a social system is unable to renew itself through adaptation or innovation, entropy increases, and scarcity becomes the dominant symptom (Guo, 2025a). The model also incorporates variables such as power distribution, access to information, and social legitimacy (Mitar, 2010).

Therefore, the framework of social entropy allows an analysis of how scarcity arises not from absolute scarcity, but from systemic failures in maintaining cohesion and equality (Guo, 2025b). In this model, social stability is seen as an organized form of energy that must be preserved to prevent systemic collapse. When the distribution of energy (or resources) becomes asymmetrical, crises arise in the form of scarcity, conflict, or collective dysfunction (Scheffran, 2023).

The approach to social thermodynamics proposed Tsekov adds a new dimension to this analysis. He argues that the second law of thermodynamics can be applied to understand that social evolution is irreversible and tends toward entropy unless new social energy is introduced. His model organizes social variables into a state equation analogous to physical systems, where the interaction between individual freedom, economic structure, and social conditions determines the stability of the

system (Tsekov, 2023b).

Without structural transformation, the system turns into disorganization. This framework is particularly useful in analyzing contemporary societies facing crises of legitimacy, environmental degradation, and extreme economic inequality. Integrating this approach with the distributive justice framework of (Sen, 2014) and Islamic economic values such as amanah (trust) and 'adl (justice) allows for the formulation of a more comprehensive analytical model (Kutval, 2024).

Therefore, this research not only develops an interdisciplinary synthesis but also a new theoretical contribution by interpreting scarcity as a symptom of accumulated social entropy. In his theory of social entropy, (K. D. Bailey, 1990) developed a three-level model of social measurement, including global, variable, and immutable variables. This model facilitates the structural analysis of social dynamics through macro indicators such as population, technology, and living standards.

His approach emphasizes the importance of open systems in society, which allow the exchange of energy and information with the external environment, thus preventing excessive entropy buildup (Jakimowicz, 2020). Bailey also highlighted the role of homeostasis in maintaining social balance, where social systems must adapt to change to maintain stability (J. Bailey, 2025). When these adaptive mechanisms fail, social entropy increases, resulting in disorganization and structural damage.

Thus, understanding social entropy is crucial in analyzing the complex and dynamic conditions of contemporary society. The theory of social entropy offers a comprehensive framework for understanding how societies undergo transformation and face challenges in maintaining order. Integrating the concept of social entropy with the approach of social thermodynamics (Tsekov, 2023a) offers a new perspective on social evolution. Tsekov advocated a minimalist thermodynamic model consisting of three social components: human, economic, and entropy, using the van der Waals equation of state to describe the interactions between these elements (Tsekov & Evstatieva, 2004).

The main finding is that the second law of thermodynamics governs irreversible social evolution, revealing the important role of social and economic freedom in this process (Bejan, 2019). This model shows that without the input of new social energy, the system inevitably tends towards disorganization and increased entropy. Therefore, this thermodynamic approach underscores the importance of innovation and structural transformation to maintain the stability and sustainability of society.

The integration of social entropy and thermodynamic theory allows for a deeper analysis of social dynamics and contemporary global challenges. This thermodynamic framework also opens up space for integrating ethical and spiritual values into social analysis. In this context, Islamic economic principles such as 'adl (distributive justice) and amanah (trust) can be seen as regulatory mechanisms that reduce social entropy (Zaman, 2018).

These values promote a fair distribution of resources and social responsibility, which in turn promotes social cohesion and system stability (Bucos, 2024). Thus, combining scientific approaches with ethical values results in a more holistic analytical framework for understanding social dynamics (Grønmo, 2023). This is consistent with the view that an interdisciplinary approach, blending scientific reasoning with a moral dimension, offers more effective solutions to contemporary social challenges.

Thus, this research contributes not only to the advancement of social theory but also provides a new perspective for designing sustainable and equitable social policies (Eizenberg & Jabareen, 2017). The integration of social entropy and social thermodynamics theory creates opportunities to understand social dynamics through an interdisciplinary lens. (Melnyk, 2021) emphasizes the need for an open systems perspective in analyzing society, where the exchange of energy and information with the external environment is key to preventing excessive entropy. In this context, social systems that can adapt to environmental changes are more stable and resilient. In contrast, closed and unresponsive systems tend towards disorganization and increased entropy (Schneider & Kay, 1994). (Beretta, 2020) adds that social evolution is irreversible and obeys the second law of thermodynamics, which means that entropy in closed systems will always increase over time. This implies that without the input of new social energies—such as innovation or reform—society will deteriorate into instability.

Therefore, an understanding of the principles of thermodynamics offers fresh insights for designing adaptive and sustainable social policies. This integration also underscores the importance of collaboration between the social sciences and the natural sciences in addressing the complex challenges of the 21st century.

Method

This study uses a qualitative approach using a conceptual literature review design to develop a theoretical framework to understand scarcity from the perspective of social thermodynamics (Snyder, 2019). The literature review method was chosen because the main goal of the study is to synthesize ideas across different disciplines and formulate new theoretical models, rather than testing hypotheses through direct empirical data (Webster & Watson, 2002). This method is particularly appropriate for exploring and building theoretical insights through critical engagement with the existing literature (Tranfield et al., 2003).

In this context, the literature review allows for the integration of discourses from Islamic economics, physics, sociology, and philosophy into an integrated conceptual synthesis. This approach is particularly suited to examining issues characterized by multidimensionality and complexity, such as the phenomenon of scarcity (Boell & Cecez-Kecmanovic, 2015). As a result, the research strategy is directed at an in-depth examination of the primary literature that is theoretically and philosophically relevant. This study does not aim for statistical generalizations but focuses on conceptual deepening. Therefore, the main criterion of validity lies not in replication but in theoretical coherence and relevance (Leedy & Ormrod, 2020).

Data sources in this study include academic books, peer-reviewed international journal articles, and scientific documents relevant to the concepts of scarcity, social entropy, and social thermodynamics. Literature was selected based on academic credibility, contemporaneity, and direct relevance to the research question. Searches are conducted through scientific databases such as JSTOR, Scopus, Web of Science, as well as open-access repositories such as arXiv for research on social physics.

The selection procedure involves several stages: data collection, critical reading, thematic annotation, and conceptual map construction. In addition, snowball techniques are used to trace cross-references from the core literature that have been identified, as suggested by (Webster & Watson, 2002) and (Wohlin, 2014). Data analysis was conducted using thematic synthesis and deductive-inductive logic, allowing researchers to develop the conceptual structure of repetitive patterns in the literature (Nowell et al., 2017). The study also adheres to the principle of transparency in source documentation to ensure analytical replicability and academic integrity.

The analytical technique in this study refers to the grounded theoretical method, although not in the classical sense established by Glaser and Strauss. The main goal is not to build new theories from field-based empirical data, but rather to formulate contextual synthesis that emerges from cross-disciplinary discourse. In practice, the study applied an open coding strategy to the reviewed literature, identifying key categories such as "social entropy", "social energy", "structural scarcity", and "systemic balance" (Charmaz, 2014).

These categories then interconnect to form coherent and reflective theoretical propositions. The result of this synthesis is a conceptual model that explains how scarcity can be understood as an expression of increased social entropy in modern society. The validity of the resulting theories is tested through internal logical coherence and critical dialogue with established theories from various intellectual traditions. In this way, research contributes to the enrichment of social theory through innovative and interdisciplinary conceptual integration.

Results and Discussion

Scarcity as a Manifestation of Social Entropy

Within the framework of social entropy theory, scarcity is not only understood as a lack of resources, but as a manifestation of increasing chaos in the social system. (K. D. Bailey, 1990) argues that social entropy reflects a degree of disorganization within the structural framework of society, which may result from imbalances in the distribution of resources, information, and power. When social adaptation mechanisms fail to respond effectively to changes in the environment or societal needs, entropy increases—manifesting in the form of scarcity such as limited access to education, health care, and economic opportunity (Moran, 2022). This suggests that scarcity is not only material but also a symptom of broader dysfunction in social systems (Blocker et al., 2023).

Conception of social entropy integrates principles from general systems theory and information

theory to analyze the dynamics of disturbances in society (Haynes et al., 2021). Social entropy, in this context, can be measured through indicators such as inequality in the distribution of resources, fragmentation of information, and institutional instability (Basheer et al., 2025). Research by (Mitar, 2010) further strengthens this framework, showing that increased social entropy correlates with higher levels of social insecurity and conflict.

In addition, the concept of social entropy intersects with value theory in economics. (Galbraith & Chen, 2025) argue that economic value is not only influenced by the scarcity of resources but also by the degree of entropy in social systems. According to their analysis, increased social entropy can devalue economic resources due to inefficiencies and disruptions in their distribution and utilization. This suggests that an understanding of social entropy can offer new insights into economic valuation and distribution policy.

In this context, the social thermodynamics approach (Tsekov, 2023a) offers an analytical model for understanding social evolution using analogies from thermodynamics. The model conceptualizes society as an open system that exchanges energy and information with its external environment. Applying the Second Law of Thermodynamics—which states that entropy in closed systems tends to increase—Tsekov explains that, without the influx of new social energy, society tends toward disorganization (Tsekov, 2023).

He emphasized that social and economic freedom plays an important role in regulating the irreversible process of social evolution. Therefore, interventions that increase public participation and individual freedom can serve as a mechanism to reduce social entropy and strengthen systemic stability (Nowak et al., 1990).

The integration of ethical and spiritual values, especially from Islamic economic thought, also serves as a mechanism to reduce social entropy. Principles such as distributive justice (*'adl*) and trust (*trust*) promote equitable distribution of resources and social responsibility, which in turn can improve social cohesion and systemic stability (Shahimi & Zahari, 2025). Within this framework, ethical values act as a form of social energy input necessary to maintain balance in the social system.

This view is in line with the argument that the integration of scientific knowledge and moral values can lead to more effective solutions to contemporary social challenges. Therefore, embedding ethical principles into social policy not only strengthens institutional legitimacy but also contributes to the reduction of social entropy (Zaman, 2018).

This approach is further supported by the concept of autopoiesis in systems theory, which emphasizes the importance of internal mechanisms in preserving the structure and function of a system. According to (Sialm, 2021), social systems sustain themselves through the process of self-reproduction. Ethical values and social norms, in this context, serve as internal mechanisms that allow the social system to maintain its integrity. Thus, the integration of moral values into the social system serves as a mechanism to reduce entropy and prevent systemic disorganization (Dinga et al., 2020).

Social Thermodynamics and the Evolution of Society

The approach to social thermodynamics developed by (Tsekov, 2023b) offers an analytical model for understanding the dynamics of social evolution by drawing analogies from the principles of thermodynamics. In this model, society is conceptualized as an open system—a system that continuously exchanges energy and information with its external environment. The Second Law of Thermodynamics, which states that entropy in closed systems tends to increase over time, is applied to social systems to explain their inherent tendency to disorganization in the absence of renewed social energy inputs (Baciu, 2024). (Tsekov, 2023b) emphasizes that social and economic freedom plays an important role in regulating this irreversible process of social evolution. As a result, interventions that increase individual agents and collective participation serve as mechanisms to reduce social entropy and foster systemic stability. In this view, entropy is not only a physical measure of chaos, but a metaphorical indicator of the fragmentation, inequality, and dysfunction of society (Fernández-Herrería & Martínez-Rodríguez, 2019).

Tsekov's model also adopts concepts from statistical physics, specifically the use of van der Waals state equations to describe social interactions (Tsekov, 2023b). By applying analogous variables – such as "social pressure" and "social volume" – this model allows for quantitative interpretations of complex social dynamics (Semenok, 2025). This framework bridges the gap

between the physical and social sciences, allowing for a more nuanced analysis of how micro-level interactions among individuals scale into macro-level organizational patterns or disintegrations.

This approach is in line with previous sociological attempts to integrate concepts from the natural sciences into social theory—most notably, (K. D. Bailey, 1990)'s work on social entropy, which combines general systems theory and information theory to analyze disorders in social systems. Bailey's framework provides basic insights into how entropy manifests in the structure of society, especially in terms of institutional failures, information asymmetry, and regulatory breakdown (Jia & Wang, 2024).

By expanding on this foundation, social thermodynamics enriches our understanding of social evolution through a framework that brings together the laws of physics and social processes (Mavromatidis, 2024). It explains how systems deteriorate when they lose renewal—whether in the form of public trust, fair policies, innovation, or inclusive governance (Kikuchi, 2023). Thus, the Tsekov model provides a strong conceptual framework for designing adaptive and sustainable social policies.

In addition, the emphasis on freedom and participation reflects a commitment to democratic and pluralistic values, reinforcing the idea that sustainable systems require agency and involvement from individuals within them. Social entropy, in this case, can be countered by empowering the community, improving civic education, and increasing transparency in institutions (Sharma et al., 2024).

In short, the model of social thermodynamics presents society not as a static structure but as a dynamic system governed by laws that are physically shaped and of deep social substance. This demonstrates the importance of sustainable energy inputs—in the form of value, innovation, equity, and agency—to maintain systemic coherence and prevent collapse. This interdisciplinary approach offers not only explanatory depth but also practical implications for policy design, crisis prevention, and long-term governance strategies (Feitsma & Whitehead, 2022).

Social Entropy and Structural Inequality

Within the framework of social entropy theory, structural inequality is conceptualized as a manifestation of increasing chaos in social systems. (Sargentis et al., 2021) argues that social entropy reflects a degree of disorganization in the structure of society, often resulting from an unequal distribution of resources, information, and power. When a society's adaptive mechanisms fail to respond adequately to changes in the environment or the needs of its members, entropy increases—evidenced by the emergence of scarcity in various forms, including limited access to education, health care, and economic opportunity (Fu et al., 2023).

The model of social thermodynamics developed by (Booshehri et al., 2021) offers a robust analytical framework to further explain this process. In his view, society functions as an open system that engages in the exchange of energy and information with its environment. Applying the Second Law of Thermodynamics, which states that entropy in closed systems tends to increase over time, Tsekov argues that without the continuous input of new "social energies"—such as innovation, reform, and civic engagement—society moves toward disorganization and instability (Tsekov, 2023a).

In this model, social and economic freedom is an important regulatory force in the evolution of an irreversible social system. Increasing public participation and ensuring access to rights and opportunities can thus serve as a mechanism to reduce entropy and restore structural balance (Haddad & Solomon, 2024). This underscores the centrality of inclusive governance and social justice in maintaining systemic resilience (P. Mehta et al., 2024).

Furthermore, Tsekov incorporated tools from statistical physics, specifically van der Waals state equations, to describe interactions between individuals in society. By analogizing variables such as social pressure and social volume, the model provides a means to conduct quantitative analysis of complex social dynamics (Ullah et al., 2024). This approach allows us to move beyond the metaphorical use of entropy, offering a measurable framework for understanding inequality as a systemic trend rather than an isolated episode of deprivation (Bucelli & Mcknight, 2021).

The alignment of this thermodynamic perspective with Bailey's earlier work is noteworthy. (K. D. Bailey, 1990) used general systems theory and information theory to study disruptions in social institutions, identifying entropy not only as decay, but as an inevitable consequence of poorly regulated systems. His work laid the groundwork for integrating the physical sciences with

sociological analysis, a direction that Tsekov extended through more formal mathematical modeling (Mitar, 2010).

Importantly, the repetition of this key argument in the literature reinforces the idea that freedom, participation, and adaptive capacity are essential to countering entropy (Cevallos, 2024). Societies that remain closed, exclusive, or rigid in structure will experience more and more rapid disruption, while those that adapt and distribute resources and power more equitably can maintain cohesion and resilience (Haldon et al., 2021).

This synthesis of thermodynamics-social offers a conceptual foundation for designing adaptive and sustainable social policies. By understanding structural inequities as a byproduct of increased entropy in systems with inadequate regulatory inputs, policymakers can better target interventions that restore systemic balance—whether through participatory reforms, redistributive justice, or institutional innovation (Zaman, 2018).

In conclusion, the integration of social entropy theory with thermodynamic modeling allows for a deeper understanding of structural inequality as a complex and emerging property of disorganized social systems. This not only shifts the narrative away from purely economic explanations but also provides a robust interdisciplinary framework for addressing inequality as a cause and consequence of systemic entropy.

Islamic Perspectives on Social Entropy and Structural Inequality

Resource scarcity is a central phenomenon in various economic, social, and environmental studies at the global level. In the global literature, approaches to scarcity often focus on quantitative aspects—the physical limitations of resources—as outlined by classical economists and natural resource theory (Sunny et al., 2024). However, Islamic thought offers a different and more holistic paradigm by placing scarcity in an interrelated moral, social, and ecological context (Hayat et al., 2023).

In the global discourse, (Sahin, 2022) thinking that highlights distribution inequality as one of the main roots of scarcity opens up space for dialogue for Islamic perspectives. Islam conceptualizes scarcity not solely because of physical limitations, but as a manifestation of moral and social imbalances that give birth to systemic damage or social entropy (Pascoe & Stripling, 2024). In other words, the scarcity in Islamic thought is a consequence of the failure of the structure of distribution and social responsibility, which is exacerbated by excessive accumulation of wealth and social exclusion (Ahmed, 2022).

The concept of *al-'adl* (justice) in Islam serves as the main normative framework that demands a fair and sustainable distribution of resources (Ali et al., 2024). The Qur'an affirms that God never does injustice even as large as an atom (Qur'an 4:40), and commands man to uphold justice indiscriminately (Qur'an 4:135). In a global perspective, this fills the ethical void that often occurs in economic analysis that is overly positivistic and pragmatic (McCloskey, 2022). This view shows Islam as a transcendent ethical tradition that provides moral validity to redistributive policies that have been often debated in the academic and public policy realms (M. Ibrahim et al., 2024).

Furthermore, Islam developed institutional mechanisms such as zakat, infāq, and waqf which are not only social charities but an integrated and systematic wealth management system to reduce inequality and social injustice (Rusydiana et al., 2025). This mechanism, in a global context, can be seen as a model of redistribution that carries important implications for political economy thinking about scarcity management, challenging the dominant individualistic liberal paradigm (Bortis, 2023). This shows the unique position of Islam as a system that blends spirituality and economics, making the distribution of wealth not only a matter of efficiency but also of social justice and balance.

In addition, Islam prioritizes the principle of *ukhūwah* Islāmiyyah (Islamic brotherhood) as the foundation of social solidarity that inhibits the fragmentation of society and encourages collective responsibility (Fansuri, 2024). In the global realm, it makes an important contribution to the formation of an inclusive society that is resilient to social and economic shocks, thus becoming one of the non-material mechanisms in overcoming social entropy (Carrillo, 2025). In the environmental aspect, Islamic thought integrates the concepts of *mīzān* (balance) and *khilāfah* (stewardship) as man's obligation to maintain the ecological order bestowed by God (Qur'an 7:56). In the global discourse on scarcity that often focuses on the exploitation of natural resources, Islam places environmental conservation as an integral part of social justice and spirituality (Nasr, 1996). This approach is in line

with thermodynamics theory which sees the overexploitation of natural resources as the production of ecological entropy that contributes to systemic collapse. Therefore, Islamic ethics on moderation (wasatiyyah) and sustainability provide a more comprehensive theoretical and practical framework for mitigating environmental damage (Kutval, 2024).

By combining these three dimensions—social, economic, and ecological—Islamic thought occupies a strategic position in the global discourse on scarcity, as a holistic approach that connects spiritual, moral, and practical values within a sustainable systemic framework. This complements and at the same time criticizes mainstream views that tend to be fragmentary and fragmented, making Islam a source of normative inspiration and applicative solutions to the challenges of scarcity and inequality in the era of globalization (Safi, 2022).

Indonesia in Focus: Social Entropy, Structural Inequality, and Islamic Ethics in the Framework of Thermodynamics

Indonesia, with its rich natural resources and extraordinary cultural diversity, faces the same dilemma as many developing and even developed countries, namely how to maintain socio-economic balance amid the pressures of globalization and modernization. Widespread social and economic inequality, accompanied by ecological crises and weak government institutions, mark an increase in social entropy that in social thermodynamics can be understood as the tendency of social systems towards disorder and loss of organized energy vital for social sustainability.

Inequality is reflected in Indonesia's stable Gini coefficient in the range of 0.38-0.41 (World Bank, 2023), as well as geographical polarization between developed economic centers and marginalized regions such as Papua and Nusa Tenggara, not only a local phenomenon. It is a micro-manifestation of global macrophenomena that shows how the flow of economic "energy" distribution—in the form of resources, opportunities, and access—is uneven and tends to be concentrated, reinforcing patterns of structural inequality that lead to social fragmentation and political instability (Piketty, 2015). This phenomenon parallels the ongoing dynamics of inequality in many countries, which shows that Indonesia is not a single case, but rather part of a global systemic pattern that requires transnational and interdisciplinary solutions (Wardani et al., 2023).

From the point of view of social thermodynamics, inequality and centralization of resources lead to the degradation of social energy leading to increased entropy, where the social system loses the capacity to effectively manage and distribute energy for the sake of balance and sustainability. This condition accelerates the cycle of social conflict, distrust of institutions, and identity fragmentation seen in various social riots and protests in Indonesia, as well as similar phenomena around the world (Tsekov, 2023a). In a global context, this phenomenon underscores the need for a new paradigm that integrates scientific, ethical, and spiritual approaches to manage such imbalances (Hosseini, 2023).

This is where Islamic values come into play as a normative and practical framework that is not only relevant locally in Indonesia but also in global discourse (A. Ibrahim, 2022). Islam, with its principles of justice ('adl), amanah (responsibility), and ukhuwah (universal brotherhood), provides an ethical foundation for the rearrangement of social and economic energies so that the system does not get caught up in a destructive cycle of entropy. Through the institutions of zakat, infaq, and waqf, Islam offers a redistribution mechanism that mobilizes social energy to balance inequality, strengthen solidarity, and improve social cohesion—a significant contribution in a global context where capitalist redistribution models often fail to reach marginalized groups (Hamzah, 2024).

Ecologically, Indonesia also reflects global challenges in maintaining the balance of the earth. The unsustainable development practices, deforestation, and pollution that occur mainly in Kalimantan and Sumatra not only damage local ecosystems but also accelerate environmental entropy that has cross-border impacts (Resosudarmo & others, 2019). In the Islamic tradition, the concepts of mīzān (balance) and khilāfah (stewardship of the earth) affirm that humans have a moral and spiritual responsibility to maintain the balance of nature as part of integral cosmic harmony (Nasr, 1996). These teachings are not only relevant to the Indonesian context, but also add a spiritual and ethical dimension to the global discourse on sustainability and the environmental crisis.

Furthermore, the problem of corruption and weak governance that exacerbates Indonesia's socio-economic entropy (Shukhratovich, 2023) is a reflection of the systemic failures experienced by

many developing countries. From a global perspective, the issue of governance and accountability is at the center of the debate on how the political and economic systems can be managed to be more responsive and equitable (Mietzner, 2018). Islam offers the principles of trust and honesty as the basic values of ideal governance, which if adopted consequentially can reduce the distortion of social energy that occurs due to the abuse of power.

At the ideological and policy level, Pancasila as the basis of the Indonesian state contains inclusive and pluralistic values that can strengthen social cohesion through an emphasis on social justice, unity, and democracy (Arifin et al., 2025). If applied substantially, Pancasila becomes a local framework that is in harmony with the principles of universal justice and solidarity taught by Islam and recognized in global discourse (Al Amin, 2024). This synergy is important to overcome fragmentation and increase social resilience, while making Indonesia a socio-ecological laboratory that harmoniously integrates local and global values (Ananta et al., 2021).

Thus, Indonesia is a real example of how the phenomenon of global social and ecological entropy is uniquely realized in the local realm, while offering solutions based on religious values and national ideology that can strengthen social and ecological systems to be more sustainable and just. This approach to social thermodynamics, which combines scientific, social, and spiritual perspectives, is an important analytical and practical tool for policymakers and scholars in managing social energy, building institutions with integrity, and realizing ecological and social balance holistically in global and local contexts (Ono, 2023).

Conclusion

This research has built a conceptual synthesis that integrates social entropy theory, social thermodynamics approaches, and Islamic ethical principles to reinterpret the phenomenon of scarcity and inequality in modern society. Within this framework, scarcity is no longer seen simply as a function of supply and demand but as an expression of increasing social entropy—a systemic disorganization rooted in the asymmetrical distribution of resources, information, and power. This perspective enriches our understanding of social dynamics by revealing that scarcity is a structural symptom rather than a technical economic anomaly. Through an interdisciplinary lens—combining Islamic physics, sociology, and spirituality—this research shows that the sustained response to scarcity must be systemic and ethical. Thermodynamic models underline that society functions as an open system that is vulnerable to chaos if it loses renewed social energy. If left unaddressed, structural inequality accelerates entropy and erodes social stability. In this regard, Islamic values such as distributive justice, social responsibility, and ecological management offer a normative framework for reconfiguring social and economic relations. This study confirms that this interdisciplinary conceptualization not only explains the complexity of scarcity but also paves the way to a transformative agenda that responds to the multidimensional crises of our era.

The implications of these findings cover both the theoretical and practical domains. Conceptually, this study advocates an expansion of the social science paradigm, proposing thermodynamic metaphors as a new way of interpreting social dynamics. It challenges the overly technocratic views found in conventional economic discourse and instead advances a framework that emphasizes the role of social systems, ethical values, and spirituality in addressing social challenges. As such, the model is not only relevant to academia but also offers actionable insights for policymakers, civil society actors, and educators seeking a more human-centered approach to development and governance. In practice, the integration of thermodynamic principles and Islamic ethical norms provides the basis for policies that are not only technically efficient but also morally and environmentally sustainable. Resource distribution, environmental management, and social development strategies will prove to be more effective when designed with awareness of the dynamics of social entropy. Social education and literacy efforts should aim to foster collective awareness of the importance of a just and resilient social system. Therefore, this research calls on all stakeholders not only to manage scarcity but to reframe our fundamental approach to society, social energy, and our moral responsibility as stewards of social balance.

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