



Principles of quantum physics: A phenomenological study of illegal mining in the construction of social justice

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ABSTRACT

Illegal mining, better known as illegal mining, is a complex multidimensional problem. This study uses a phenomenological lens to explore the deep meaning of the experiences of illegal mining actors in the Merangin Regency, Jambi. The findings of this study consistently show that severe economic pressures, combined with limited access to education and job opportunities, are the main drivers of community involvement in illegal mining activities. Informants explicitly stated that they knew their actions' legal and environmental implications but felt trapped in a difficult situation. By adopting a quantum physics lens, this study emphasizes that individuals, like subatomic particles, are often in a state of superposition between various choices, trapped in moral and economic dilemmas. This approach offers an innovative analytical framework for understanding the complexity of contemporary social problems. To overcome this problem, comprehensive efforts involve expanding economic opportunities, developing community capacity, and enforcing fair and community-friendly laws. Overall, this study highlights the importance of understanding the social and economic contexts that underlie community involvement in illegal mining activities. By adopting an interdisciplinary approach combining qualitative methods and quantum physics concepts, this study significantly contributes to developing more effective policies and intervention programs in addressing this problem.

Keywords: illegal mining, quantum law, justice, uncertainty, superposition.

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INTRODUCTION

Industry dynamics in Indonesia have undergone many changes, especially in the agricultural sector, which has brought about a transition in the livelihoods of the Indonesian people, especially in the Merangin Regency. The rural livelihood system is where most of the people are farmers with natural rubber plantations. From 2010 until now, people have started to switch to becoming oil palm farmers and carrying out illegal mining due to the decline in world rubber prices (Usop and Iskandar, 2020).

Illegal mining raises complex problems involving various aspects such as economics, environment, law and society. This event will include uncertainty regarding the impact on the environment and the law and social implications. This study will explore the deep meaning of the experiences of illegal mining actors and conceptually analyze the phenomenon, which will be linked to the views of the concept of quantum physics.

Several related studies such as Pranita (2023), state that the conceptual approach of the philosophical concept of science such as quantum physics can help explain and find the best research methodology from an Islamic perspective and finance. Research from Samekto (2010) states that quantum physics theory should be able to be a conceptual basis for viewing metaphysical phenomena of the universe, including social phenomena. Research from Marilang (2017) states that the concept of modern quantum mechanics with its theory of relativity has contributed a lot to Satjipto Rahardjo in constructing his popular ideas with the term progressive law.

Based on previous research, applying the concept of superposition and uncertainty in quantum mechanics allows for concrete definition and operationalization in complex social contexts such as illegal mining. However, there is still minimal research that examines it. Superposition in quantum mechanics describes a state where a system can be in several states simultaneously. While the uncertainty put forward by Heisenberg states that the more accurate a particle is, the less precise it will be to predict its momentum, and vice versa (Wolff, 2014). Through these two concepts, social phenomena can be indicated fundamentally in the uncertainty of the universe.

In illegal mining, various conflicting interests often overlap and are difficult to separate. For example, the economic interests of mining activities usually clash with environmental and social interests. This complex and dynamic situation can be analogized with the concept of superposition in quantum mechanics. In addition, the high uncertainty in cases of illegal mining, both in terms of evidence, environmental impacts, and perpetrators, can be associated with the Heisenberg uncertainty principle.

The human rights view and the supremacy of law view, in this case, clash with each other, which gives rise to contradictory statements when only looking at one paradigm so that the problem of illegal mining can never be resolved until now. Even if the act was done only to fill a hungry stomach, Cicero in Hagman (1764) expressed the argument, namely "Salus Populi Suprema Lex Esto" which means that human safety is the highest law, this can be interpreted that even the constitution can be violated for the safety of the people, including safety to survive amid increasingly high economic pressures. Even if this statement is linked to Pancasila as a guiding idea for life in Indonesia, it is undoubtedly essential for the Government to find a

hegemonic and just solution to this problem (Gerung, 2018).

RESEARCH METHODS

This study aims to understand the deep meaning of the experiences of illegal mining perpetrators in Merangin Regency, Jambi Province, which will then use a conceptual approach to see aspects of justice through concepts in quantum physics in viewing this social phenomenon. Using a phenomenological approach, this study explores the perspectives and feelings of individuals involved in this activity. Specifically, this study will examine how social, economic, and environmental contexts influence individuals' decisions to engage in illegal mining. Through an in-depth analysis of the perpetrators' narratives, this study is expected to contribute to a more nuanced understanding of the complexity of the problem of illegal mining in Indonesia. A conceptual approach is also used to provide analysis and a new perspective from our perspective on this illicit mining phenomenon.

The analysis of meaning obtained from interviews with individuals using phenomenological investigations can be very informative and profound (Alifuddin, Chaer, and Suud, 2020). The phenomenological approach, as a form of qualitative research, has a direction to visualize shared meaning based on the life experiences of informants about the phenomenon being studied (Salama et al., 2022). In an attempt to capture the essence of a person's lived experience, we aim to explore the world as experienced by each individual, then draw conceptually from what is described by modern quantum physics concepts to explain uncertainty and the justice that should be achieved (Usop and Iskandar, 2020). Our study not only provides insight into the daily lives of illegal miners but also aims to humanize a community amid economic turmoil in its own country whose voices are often powerless, unrecognized, or silenced (Ikhsan 2014).

The selection of this research sample used a purposive sampling technique where the sample was taken based on specific criteria that matched the research (Lenaini 2021). Purposive sampling samples were taken based on subjective assessments from researchers (Firmansyah and Dede, 2022). The sample in this study was the general public who lived in Merangin Regency, carried out illegal mining activities and were over 18 years old. Because this research topic is sensitive and challenging, many people are unwilling to become informants. Researchers only found five respondents who agreed to participate in this study. Before the interview, we briefly arranged an appointment in the form of a place and time with the informants, during which the five informants were interviewed at different locations and times.

Informants were asked open-ended, unstructured questions and only tried to explore the relationship between mining carried out with the economy, environment, and law. When collecting this data, a relaxed and informal atmosphere was maintained so informants felt more comfortable and calm in providing their views. We ensured that there were no risks associated with their participation. During data extraction, participants' names were coded anonymously, allowing them to respond in their own words and encouraging them to share sensitive issues with assurance of confidentiality.

In this study, we put ourselves in the shoes of the selected participants, regardless of who or what they are. In terms of analysis, this study used every step of phenomenological reduction,

including epoche or bracketing, horizontalization, and grouping meanings into themes. Through epoche (bracketing), we temporarily set aside previous understandings and knowledge, prejudices, biases, beliefs, and assumptions about the phenomenon of interest while listening to the informant's narrative (Edie, 1974). This allowed us to clarify preconceptions and explore the phenomenon more thoroughly (Springborg, 1975). The analysis in this study included data collection, data narrative, data reduction, data interpretation and implications, and conclusion. Through the combination of the above approaches, researchers could better interpret and understand experiences and perspectives related to illegal mining cases.

RESULTS AND DISCUSSION

This research was conducted in Merangin Regency, Jambi. This area covers an area of 7,679 km² with varied topography, from lowlands to mountains as high as 1,206 meters above sea level. Geographically, Merangin is located at coordinates 101.32° - 102.50° East Longitude and 1.28° - 1.52° South Latitude (Merangin, 2017).

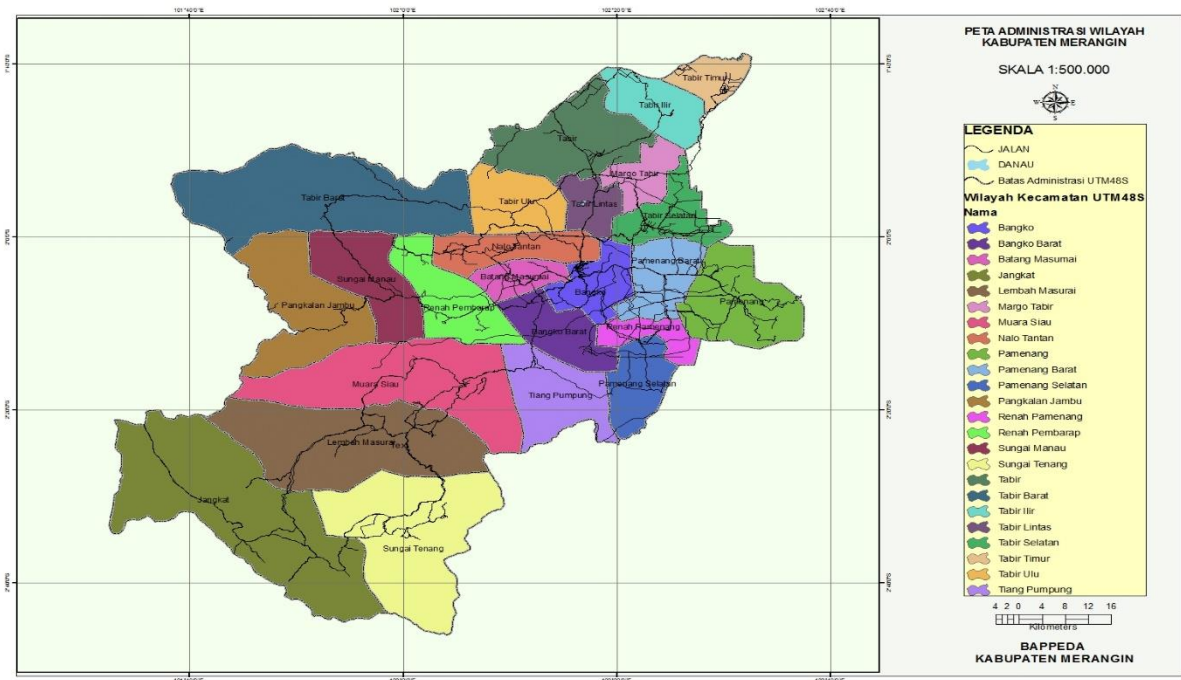


Figure 1. Administrative Map of Merangin Regency

Figure 1 shows the geographical location of Merangin Regency is very strategic. This area directly borders several other regencies in Jambi and Bengkulu Provinces (Merangin, 2017). To the east, it borders Sarolangun Regency; to the west, it borders Kerinci Regency, which is famous for its natural beauty; to the north, it borders Bungo Regency and Tebo Regency, and to the south, it borders Rejang Lebong Regency which is in Bengkulu Province (Merangin, 2017).

Table 1. Merangin Population Data 2022

Gender	Amount	Total
Male	181.850	357.577
Female	175.727	

Table 1 shows that in 2022, the Population in Merangin was 357,577 people, with 181,850 male residents and 175,727 female residents (BPS, 2023). Around 8.90% of the Population in Merangin Regency still live below the poverty line, with an average income of less than 537,492 thousand rupiah per month (BPS, 2022).

1. Illegal Mining Phenomenon

In this study, we sought to gain a deeper understanding of the participants' personal experiences through interviews with informants. The shared stories were then carefully examined by grouping words or frequently appearing topics. Three main themes emerged from this process: feeling like there was no other choice, a sure and easy way to get money, illegal acts and environmental destruction.

a. Feeling There Is No Other Choice

This subtheme explains how illegal mining affects participants' feelings of helplessness or lack of other options. For example, N1, with the initials AN, 33 years old, married with three children, said:

I have no other way to survive. In the past, my parents had a lot of land, but it had been divided up among their children, and I, as a child, because of the need to live, sold all the fields so that to eat every day, I had to work every day. With Kwan's invitation to work, I can support my family daily.

Although there are informants who are helpless, some feel too weak to look for other sources of livelihood because they are aware of their position as a weak economic group with low human resources. As mentioned by N3 with the initials AP, 42 years old, has a family with two children, said:

Yes, I can't refuse this job. I can't even protest anyone to do it, even though my body and energy are drained all day, but life goes on; my family and I need to eat and from this illegal mining, even though we get more than 200 thousand a day, it is also uncertain, sometimes we don't even have enough for our daily food needs.

In another case, N2, with the initials BS, a 30-year-old father of 4 children, said:

I often feel that this is not good for the next generation because the forests and land for farming and gardening have run out; however, if there is a better solution to guarantee our lives from the local Government, it might be better.

One of the informants, N4 with the initials PE, aged 20, newly married and has one child, said:

We are like the Government's stepchildren; they know nothing about our lives in Merangin. Our votes have been taken, but the development of our region has never been carried out. We have to find a way to live from day to day. We can't rely on the existing Government; instead, we will be the ones who demand too much.

In contrast to the previous informant, N5, with the initials SU, aged 49 years and has six children, stated:

I prefer to work elsewhere if there is any. Still, it is hard to find work now; if we want to work in an office, we are only high school graduates. We are already old, if we want to do gardening, we have no inheritance and no other skills other than relying on our strength, in the past it was easier, many wealthy people had rubber plantations so they

could become rubber tappers, now where are their rubber plantations anymore, there are lots of oil palms here, and they don't need many workers.

In this study, all informants had the same feeling that opportunities for other work no longer exist, so illegal mining is the only way to survive daily; if you don't work, you won't eat.

b. Certain and Easy to Get Money

In this sub-theme, most participants who work in illegal mining, such as N1 and N3, think that this job is easy and they get money on the day they work because the results of the mining are immediately sold on the same day, N2 stated that:

Before doing this job, I had worked as a casual labourer on a local palm oil plantation. However, that was not the work every day, maybe only a few days a month, and the daily salary was not enough to cover our family's living expenses.

Some participants also felt that they did not have other skills and abilities to use to earn money, such as N5:

I don't have any skills, I want to do other work, apart from this energy that I have, moreover, even though this job is sometimes good, sometimes it's just enough to eat, but it gets paid every day so that the family at home can eat.

Many participants felt helpless to complain anywhere but could not even though they were locked in poverty and social vulnerability without being able to work or other livelihoods that could be quickly done and certainly receive wages every day. As stated by N4:

I am too old to look for another job that is full of uncertainty, unlike this job, if there is water, we will continue to work whenever it rains or not, because this is a matter of food, the work is also fun, there are lots of friends to chat with because we are in a group, not alone.

In this context, the inability of all participants to see opportunities and other jobs is due to the certainty and ease of this illegal mining work.

c. Unlawful Acts and Environmental Destruction

This subtheme reflects how informants are aware that this is a violation of the law and damaging to the environment, as explained by N1 below.:

We understand that this is damaging to the environment; where after this mine is finished, there will be no more gold, or our income will drastically decrease in this location, so we automatically leave this land as it is, even if we want to plant it, it can't be done anymore, extra handling is needed to be able to grow again on this former mining land, but we mine on our land or other people's land with a profit-sharing system, no one is harmed, both get profit.

Another thing was also conveyed by N2 and N3, who thought that mining did not damage the environment, where the damage was our people mining in locations that could not be planted, sandy and rocky soil where production plants could rarely grow. In contrast to that, N4 and N5 argued:

I understand this is damaging the environment and is clearly against the law, but we are not mining to make us rich or eat like everyone else (N4).

N5 believes that the law should not see us as enemies; after all, we are also human beings, and there is no solution from the Government and the state; we also need to live; we are

responsible for the environment where we live, we do not damage other people's environment, we mine on our land, our welfare should also be taken care of, it is not that the law considers us as pests.

In this sub-theme, all informants understand that the environment will be damaged and illegal mining is against the law. Still, they feel that solutions other than law enforcement and prevention of environmental pollution need to be found because they work not to get rich but to survive. This study may be the first to examine the complexity between the phenomenism of illegal mining and the construction of quantum law in physics to seek social justice as aspired by the founders of the Indonesian nation in Pancasila verse 5. This study can be a breakthrough because no previous research has been conducted on efforts to seek social justice from a phenomenological perspective and the relationship between the concept of quantum law and social justice. Therefore, the lack of literature on this phenomenon inspired this study to explore the phenomenon of illegal mining and the suitability of the concept of quantum law in physics in answering the social justice aspired by the nation's founders. In addition, the lack of previous narratives on these themes has prevented the discovery of many reports that have provided further information on the complex problem of systematic justice. Thus, the results of this phenomenological study are significant because they provide an in-depth analysis of an unusual topic to help readers appreciate differences of opinion, humanity, and changes in the social justice paradigm.

It is important to emphasize that although justice is different for everyone and is still a long and endless debate among scientists, it is essential to look at it from various perspectives to change certain paradigms about existing laws and policy steps that must be taken. According to Husserl, with phenomenology, every phenomenon of thought, emotion, or memory experienced can be investigated and analyzed (Anshori, 2018), including the experiences and opinions of individuals actively carrying out illegal mining activities. The phenomenon of hungry stomachs in the country itself has become a frightening spectre for most people, especially in big cities; the tendency of humans to do anything to survive can be seen in various natural phenomena. However, the way to survive humans that damage the environment, such as illegal mining, is often criticized by political elites and law enforcers who only see it from the general perspective of law enforcement, not from the social problems of the lower classes who scream and cry because they are hungry. Furthermore, the awareness of illegal miners is that they are aware that their behaviour is wrong towards nature, and nature demands that they continue to survive so that there is no choice available for those with low human resources and less attention from the Government.

Given the importance of quality of life and social welfare, this is expected to lead to the first and second themes, namely the feeling of having no other choice, easy work, and the certainty of getting money to stay alive. Low human resources and lack of attention from good Government management cause the community's powerlessness, especially informants in this phenomenon, to work in other fields. This impacts family welfare and social inequality if they choose not to work. Furthermore, people who make mistakes experience legal discrimination and social disparity in the imposition of a guilty stigma for those who only fill their hungry stomachs by working illegally.

The forced cessation of illegal mining activities can cause other legal problems such as theft and other criminal behaviour because of the tendency of individuals to fulfil their life needs, especially eating and drinking. Given the importance of the environment and legal awareness, this phenomenon is expected to lead to the third theme. Although all informants are aware of their mistakes, no choices and directions resolve existing social problems, such as fulfilling life needs with steps and guidance from Government officials who can balance their current economic and social inequality. If we prioritize law enforcement without resolving and seeking long-term solutions, the subsequent negative impacts will lead to social rebellion and severe and widespread criminal behaviour.

2. The Concept of Quantum Physics in the Construction of Social Justice

As researchers and scientists, we must view knowledge as something that continues to change and is dynamic, as well as social sciences and law (Bojangan, 2017). In science, especially physics, there have been several revolutionary changes that continue to change, starting from Albert Einstein's theory with his theory of relativity, Max Planck's theory of radiation and black bodies, Arthur Holly Compton's theory of the Coupton Effect and Max Born with the theory of probability density function in the Schroedinger quantum mechanics equation, Werner Heisenberg with his uncertainty principle theory, Niels Bohr with his theory of the hydrogen atom spectrum, Erwin Schrodinger with his theory of superposition and successfully providing a reasonable explanation of Broglie's theory, Richard P. Feynman with his theory of quantum electrodynamics, Wolfgang Pauli with his theory of the Pauli exclusion principle, Paul A. M. Dirac with his theory of spin and magnetic moment of electrons and Enrico Fermi with his theory of beta decay (Bojangan, 2017). Several scientists and their theories contributed from classical to modern physics.

According to Satjipto Rahardjo's view in Swardhana (2010), by taking the pragmatic changes from classical physics theories to modern quantum physics as they are today, such changes should also be possible in today's social sciences and laws. The theoretical views of physics, such as Werner Heisenberg's uncertainty principle theory, state the uncertainty principle that the more precisely the momentum or position of a particle is known, the less it can be known about other particles (Cassidy, 1992) (Jesi Pebralia, 2020). If the momentum of a particle is known, the position cannot be measured, and vice versa (Wolff, 2014) (Saputra, Supriadi, and Prastowo, 2019).

$$\Delta x \cdot \Delta p \geq h/4\pi \quad (1)$$

Where Δx is the position uncertainty, Δp is the momentum uncertainty, calculated by the formula $\Delta p = m \cdot \Delta v$, where m is the mass of the particle, Δv is the velocity uncertainty, and h is Planck's constant (Mackinnon, 1977). Heisenberg's uncertainty principle states that it is impossible to measure two quantities simultaneously, such as the position and momentum of a particle, with perfect accuracy (Busch, Heinonen, and Lahti, 2007).

The relevance of the concept of quantum physics in viewing social phenomena such as justice and especially in legal and social sciences could occur at several points, such as Satjipto Rahardjo's views in legal science are inspired by the approaches and perspectives of quantum

physics law in interpreting the universe.

Even though justice is like a mysterious object that continues to be debated from Roman times to the present (Marilang, 2017), to see and seek justice itself, the approach of the superposition principle of quantum physics law is used, which is attractive to offer to see the application of the law itself from the perspective of social implications and legal science. The phenomenology described in the first discussion theme about illegal mining can be seen as two different perspectives in one construction of legal violations where the supremacy of law must clash with human rights that cannot be taken simultaneously as in quantum physics, the principle of superposition. Even in the famous legal doctrine and proposition we hear in legal science, which reads "Salus Populi Suprema Lex Esto" which means human safety is the highest law (Hagman, 1764).

Polanyi in Samekto (2010) said that although the primary material of science is the impersonal physical world, activities in scientific activities cannot be separated from personal experience. Through the phenomena that occur in the research area when viewed from the perspective of the perpetrators and the social implications that they have achieved by carrying out these activities, it is a mistake only to apply positive law that applies to small-scale illegal mining perpetrators on the other hand, even so, environmental damage is increasingly widespread which will worsen life for the next generation.

At this stage, it is possible to choose defensive law enforcement within a progressive legal framework or social resolution by finding the leading solution to the problems that occur in the area; from the three sub-themes that have been described, the main issue was found, the informant's reason was their helplessness in finding, choosing other jobs for daily living, this is triggered by low human resources and lack of skills and opportunities and development of creative economy in the area as an initial trigger for the movement of the local community's economy. This is also a challenge for the Government as a manager of life and for guaranteeing social welfare based on the guiding idea of the Indonesian nation, namely Pancasila (Gerung 2018). The inability of leaders to realise these ideals must be the responsibility of both central and regional leaders.

Promoting the importance of awareness of the law alone in solving socio-economic and environmental problems that occur without offering justice for those looking for a bite to eat for their daily lives is contrary to the concept of human rights that is glorified in Indonesia. Unfulfilled fundamental human rights can trigger even worse behaviour and actions, such as criminal behaviour. Erwin Schrodinger, with his superposition theory in his famous experiment with the name Schrodinger's cat in this scenario, Schrodinger's cat exists in a state where it is simultaneously alive and dead until observed (Wineland, 2012). This paradoxical situation highlights the dual nature of quantum objects, where they can exist in multiple states until a measurement is made (Wineland, 2012).

This experiment was done by imagining putting a cat in a box with a device that has a 50% chance of releasing poison after one hour (Wineland, 2012). Schrodinger highlighted the paradox where, until the box was opened, the cat existed in a superposition of being simultaneously alive and dead. The principle of superposition in the context of waves states that when two or more waves pass through the same region of space, the resulting wave

displacement at any point is the algebraic sum of the individual wave displacements at that point, which can be formulated with the following mathematical equation:

$$y(x,t) = y_1(x,t) + y_2(x,t) \quad (2)$$

Where $y_1(x,t)$ is wave 1 and $y_2(x,t)$ is wave 2 and $y(x,t)$ is the resulting wave. The wave equation $y(x,t) = y_1(x,t) + y_2(x,t)$ not only describes the physical superposition of waves but can also be an interesting metaphor for understanding complex social dilemmas. In the context of the phenomena described in the first theme, this equation seems to describe a situation where individuals or groups of people are caught between two opposing 'waves'.

On the one hand, individuals are fully aware of the violation of the law or injustice that occurs. This is like the first wave that brings energy and awareness of the truth. On the other hand, they are also faced with brutal economic realities where the needs of life are pressing. This second wave brings pressure and demands for survival. Individuals often feel adrift when these two waves meet, not knowing what to do.

This perspective offers a more nuanced way of looking at analyzing social situations. Informants in research often feel placed in a difficult position where they have to choose between principle and pragmatism. They are aware that their actions may violate norms or laws, but at the same time, they feel they have no other choice. In finding innovative solutions, we must understand that social problems are often multidimensional. There is no single solution that can be applied universally. Understanding the social, economic, and cultural context is essential in designing effective interventions. In addition, it is also necessary to actively involve the community in finding solutions so that they feel they have ownership of the changes that occur and that the desired social justice can be achieved.

CONCLUSION

In this study, we investigated the lived experiences and meanings of doing illegal mining work. This illegal mining is motivated by the absence of other options to continue to earn money for a living; illegal mining is a job that is certain to receive cash after working and awareness of unlawful acts and environmental damage. Each participant had similar and almost the same opinions on the sub-themes that were concluded from the interviews. The results show that the informants are low human resources with a high school/vocational high school education level and a lower economy; this encourages them to do any work that can be done to meet their living needs, solutions for providing employment and developing skills for the local community need to be carried out by the Government.

They are adapting Heisenberg's uncertainty and superposition concepts in quantum physics to analyze social dilemmas, especially legal violations due to economic pressures. Just as particles in quantum physics can be in multiple states at once, individuals in society are often caught between awareness of legal violations and financial demands. The wave equation in quantum physics becomes a metaphor to describe this situation, where individuals seem to oscillate between two opposing 'waves'. This perspective offers a more nuanced way of

understanding the complexity of social problems. It encourages the need for holistic solutions involving society and considering the broader social, economic, and cultural contexts. Thus, this study suggests that quantum physics can help analyze and find solutions to complex social problems in pursuing social justice.

Furthermore, the results of this study will increase the reader's understanding of the causes of illegal mining in the research area. For future research, it is essential to expand the literature. Given the increasing cases of widespread and massive illicit small-scale mining, the relevant Government and law enforcement need to be interviewed to find preventive solutions related to the problems found in this study.

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