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COLONIAL ROAD AND IRIGATION INFRASTRUCTURE IN KERINCI: CIVIL ENGINEERING, HYDROLOGY, AND ENVIRONMENTAL IMPACT ANALYSIS

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Colonial Kerinci; Hydrology;Infrastrure

ABSTRACT

This study discusses the development of road infrastructure and irrigation systems during the Dutch colonial period in Kerinci as part of technical, economic, and spatial management strategies. This study employs a qualitative approach with methods based on digital archives, colonial photographs, historical maps, and academic secondary sources. The data were analyzed through visual interpretation, gravitational hydrology analysis, and tracing the historical context of the development. The results show that the irrigation and road systems built by the colonists were designed using simple yet effective civil engineering principles, such as utilizing natural elevation, reinforcing soil with local materials, and integrating drainage and transportation functions. This infrastructure not only served as a logistics distribution and agricultural irrigation but also as an instrument of territorial control and landscape transformation. This research makes a new contribution by interpreting colonial infrastructure as environmental engineering works that were adaptive to the physical conditions of Kerinci. Thus, this study enriches our understanding of colonial engineering heritage and its relevance to conservation, historical reconstruction of space, and environmental sustainability studies in tropical mountainous regions.

I. INTRODUCTION

Infrastructure development during the Dutch colonial period in the Indonesian archipelago was not merely a technical project, but rather a political, economic, and spatial control strategy (Zaqi al zamani, 2022). Infrastructure can be understood as a connected and mutually supportive physical system, including transportation networks, irrigation, buildings, and public facilities that serve to meet basic human needs (Adris.A.Putra & Susanti Djalante, 2016). The presence of infrastructure is an important factor in expanding public access to resources and increasing regional productivity, which ultimately has an impact on economic growth and social welfare. Regions with more comprehensive infrastructure systems generally demonstrate better quality of life and higher levels of welfare (Sandy & Kusumastuti, 2023). In a historical context, infrastructure development during the colonial period was not only intended to strengthen economic activity, but also played a strategic role in territorial control and military mobilization (Putra & Ghazalie, 2024).

One of the areas that underwent colonial infrastructure development was Kerinci, which in the early 20th century began to be opened up through the construction of roads and irrigation systems (Aldy et al., 2021). This infrastructure was designed to connect the interior regions with the colonial administrative center while facilitating the distribution of agricultural commodities such as rice, coffee, and cinnamon. Kerinci's geographical conditions, which include high rainfall, fertile volcanic soil that is prone to erosion, and undulating terrain, required the application of civil engineering and hydrology principles in its construction (Darmawan et al., 2023). Colonial archive photos show that irrigation channels were built parallel to roads, using gravity-based designs to ensure water distribution without mechanical pumps. The choice of stone for the channel walls reflects considerations regarding the stability of volcanic soil, which is easily eroded when high-velocity water flows through it.

Studies on colonial infrastructure in Indonesia generally emphasize historical and political aspects of power, as seen in research Firmansyah & Mirzachaerulsyah (2023); Maris (2022); Harkantiningsih (2014) which shows that infrastructure development during the colonial era was not only oriented towards mobility and economic production, but also served as a mechanism for integration and administrative control. However, studies on the technical aspects of water and road system development are often neglected, especially in mountainous areas such as Kerinci. Furthermore, from a colonial civil engineering perspective, irrigation systems were generally designed based on the principle of gravitational hydrology, which utilizes natural elevation as a source of energy to drive water flow (Smits, 2019). Meanwhile, research on engineered landscapes shows that colonialism also changed spatial structures, settlement patterns, and ecological cycles through planned development based on technical logic (Raffles, 2015). Today, this article lies at the intersection of technical history, environmental hydrology, and colonial spatial studies.

Although physical remnants of this infrastructure can still be found in Kerinci today, scientific studies on its technical aspects remain limited. Most previous studies have focused on the social history, colonial politics, or cultural dynamics of the Kerinci community. Several previous studies have touched on Kerinci from an infrastructure perspective, including: Darmawan et al., (2023), Pratama & Muktiali, (2016), Yulanda & Frinaldi, (2023). To date, there has been little research examining colonial infrastructure through a multidisciplinary approach that integrates historical, civil engineering, hydrological, and environmental analysis to understand how these systems were built, operated, and influenced long-term landscape transformation. This research gap shows that colonial infrastructure in Kerinci has not been understood as the result of the application of engineering and environmental physics, but is still viewed as a static historical relic.

This research offers a new perspective by examining colonial infrastructure through visual analysis of archives, field observations, and an environmental hydrology-based civil engineering approach. The novelty of this research lies in the use of colonial visual documentation as technical data, rather than merely as historical archives. This approach enables the identification of design elements such as gravity flow, hydraulic slope, road drainage systems, and material selection relevant to the dynamics of the tropical mountain environment. In addition to technical reconstruction, this study evaluates the impact of infrastructure development on spatial pattern changes, ecological transformations, and the formation of engineered landscapes that still survive today.

This research not only contributes to the reconstruction of the history of colonial infrastructure development, but also enriches our understanding of the relationship between colonial technology, environmental physics, and spatial change. This study focuses on reconstructing the history of colonial road and irrigation infrastructure development in Kerinci and conducting technical analysis based on civil engineering and gravitational hydrology principles, with the aim of understanding how these systems shaped spatial and environmental change during the colonial period and their impact on the current conditions of the region.

II. METHODS

This study uses a qualitative-descriptive approach with a library research method. This approach was chosen because the study focuses on historical reconstruction and technical analysis of road infrastructure and irrigation systems during the Dutch colonial period in Kerinci based on textual, visual, and cartographic sources, without conducting experiments or quantitative field surveys (Adlini et al., 2022). The research data was obtained from four main sources, namely: (1) colonial archives in the form of administrative reports, newspaper articles, and technical documents accessed through the KITLV and Delpher digital collections; (2) visual documents, including old photographs and maps depicting the physical condition of colonial roads and irrigation systems; (3) secondary scientific literature in the form of journal articles, books, and

research reports relevant to the topics of colonial infrastructure, civil engineering, hydrology, and environmental studies; and (4) contemporary spatial data from Google Earth and Google Maps to remap locations recorded on colonial maps.

Data collection was conducted through systematic searches using keywords such as Kerintji/Kerinci, irrigatie, weg, and other technical terms in Dutch and Indonesian. All sources were then selected based on their relevance to the research topic. Data analysis was conducted through qualitative analysis based on document interpretation, which included critical reading of written archives, analysis of historical photographs, and interpretation of maps through comparison between colonial images and current conditions in the region. Principles of civil engineering, gravitational hydrology, and soil mechanics were used as an interpretive framework to understand the technical logic behind colonial infrastructure development. Data validity was maintained through cross-source triangulation, which involved matching information from written archives with visual evidence and spatial data, as well as verifying findings through secondary academic literature. This step ensures that the resulting interpretations are not only descriptive, but also have a valid technical basis and historical context. This research method allows for a comprehensive analysis of the form, function, and impact of colonial infrastructure in Kerinci through the integration of historical, technical, hydrological, and environmental aspects.

III. RESULT AND DISCUSSION

Historical reconstruction of Colonial Road Infrastructure ini Kerinci

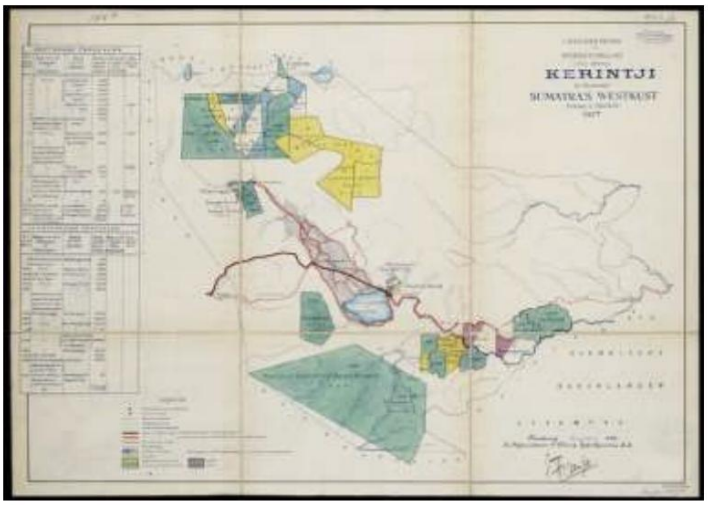

Figure 1.
Map kerintji, collection kitl leiden

a search of historical archives, colonial photographs, and old maps shows that the construction of road infrastructure and irrigation systems in kerinci during the dutch colonial period was a planned and gradual process that began in the early 20th century. digital archives from kitlv and delpher show that this project did not stand alone, but was part of a broader colonial agenda to

open up access to inland areas, strengthen administration, and support large-scale agricultural production (hudaya et al., 2023) . Institutionally, this project was led by the Burgerlijke Openbare Werken (BOW) as part of the implementation of the Ethical Policy, Which extended into the interior of Sumatra after the local authorities in Kerinci submitted in 1903. Various documents show that the colonial government considered Kerinci a strategic region due to its potential for agricultural commodities, particularly rice and coffee, so infrastructure development was directed towards creating distribution channels and irrigation networks that supported sustainable production (Agustina, 2020). In addition, colonial photographs show Dutch officials conducting field inspections, confirming that construction was subject to strict technical and administrative supervision.

However, behind this technical precision, the large scale construction of this infrastructure involved the mobilization of local labor through a sytem of compulsory labor (heerendiensten), which marked the transition of society from a subsistence economy toward integration into the colonial market economy. Thus, these preliminary findings suggest that infrastructure development in Kerinci during the colonial period was not only a response to technical needs, but also a strategy for sustainable control of space (Hallermann, 1915).

Figure 2.
Aanleg van de Kerintjiweg di Kerintji (KITLV, 1918a)

Based on colonial newspaper archives found through the Delpher platform and the KITLV visual documentation collection, the process of road and irrigation system construction in Kerinci can be traced back to between 1908 and 1930, with several important phases. In the initial phase, the colonial government prioritized the opening of access routes from the highlands of Kerinci to the administrative center and agricultural production areas. Archival records show that this

development was led by a controleur van Kerintji who collaborated with colonial engineers and locally recruited laborers (heerendienst).

The mobilization of labor through the heerendienst sytem reflects a paradox of the ethical Policy in the interior regions, where the infrastructure modernization program often relied on the physical labor of the local population. Furthermore, the involvement of the controleur van Kerintji in Overseeing this project demonstrates that road construction was not merely a technical matter of transportation, but rather a strategy for the bureaucratization of space to ensure political control and the efficiency of tax collection in the highlands. Over time, up until 1930, the developed irrigation network began to shift traditional subsistence farming patterns toward a more centralized system of export commodity plantations, which permanently altered the socio economic structure of the Kerinci community.

The Construction of Roads and Irrigation Sytem In Kerinci During the Dutch East Indies Period

Road construction was carried out following a linear design pattern characteristic of Dutch colonial infrastructure, namely straight lines as far as geographical conditions allowed, taking into account the contours and elevation of the area. Along with road construction, an irrigation system was built in parallel to support the opening of intensive agricultural land, especially rice fields and colonial plantations. This can be seen in a number of photographs showing irrigation channels built right next to the road, indicating that the two infrastructures were designed as a single planned spatial system. This historical reconstruction shows that the construction of roads and irrigation in Kerinci was part of a colonial strategy that not only aimed to facilitate mobility and production, but also to create a new spatial structure that controlled the flow of people, commodities, and water resources.

Figure 3.

Colonial irrigation in Kerinci (KITLV, 1918)

The photo above shows that road and irrigation canal construction in Kerinci during the colonial period applied civil engineering principles oriented towards structural stability and adaptation to volcanic soil conditions. The main material used was local andesite stone, which was manually arranged as the foundation for roads and retaining walls for irrigation channels. The choice of this material was not accidental, as this type of stone has relatively strong mechanical properties, is resistant to lateral water pressure, and can reduce the risk of erosion in wet soil (Aldy et al., 2021). In addition, the road structure was built slightly higher than the surrounding land, indicating an awareness of the need to avoid flooding, especially during the long rainy season in tropical mountainous regions. The parallel layout of the road and irrigation canal infrastructure also demonstrates integrated planning, in which human mobility and water flow are designed to work complementarily within a single spatial engineering corridor. Colonial infrastructure construction in Kerinci was not only functional, but also reflected the application of civil engineering principles based on specific natural conditions.

The managementof human flow through this linear infrastructure has indirectly reshaped the social structure of Kerinci society. New roads created hubs of activity (the embryos of new markets and settlements) that triggered a shift in settlement patterns from the interior of the hills toward the peripheries of the main roads. This resulted in the weaking of traditional authority based on indigenous communities in regulating the mobility of their members, as the community's movement was now confined to corridors that were easily monitored administratively by the colonial government.

Figure 4.
irrigation construction (KITLV, 1918)

The red water channels shown in the colonial documentation above demonstrate the mature application of hydrological planning in infrastructure development in Kerinci. The straight shape of the channels, with measured cross-sections and relatively uniform dimensions, indicates that

this construction was designed with consideration for flow capacity, hydraulic pressure, and the need for water distribution to surrounding agricultural land (Aldy et al., 2021). The stable flow without eddies shows that the slope of the channel follows the natural gradient of the slope, allowing water to flow continuously without mechanical assistance. This design reflects the colonial understanding of water dynamics in mountainous areas, where elevation is a key factor in maintaining constant flow and avoiding energy loss due to friction or turbulence.

The presence of a reinforcing structure in the form of a stone arrangement on the side of the channel demonstrates the dual function of this system. The channel not only carries water for irrigation purposes but also serves as a drainage system that directs rainwater runoff to prevent damage to the roadbed located above it. The use of local stone as reinforcement material demonstrates an adaptive strategy in dealing with environmental challenges, particularly the volcanic soil of Kerinci, which tends to be fragile when exposed to high-velocity surface flows. In addition, the vegetation growing at several points shows an additional function as natural soil retention (bio-stabilization), which over time also strengthens the canal structure through root binding and increased soil cohesion.

The difference in elevation between the road and the canal reveals an engineering strategy that separates transportation functions from water management systems (Sukmara Christian Permadi et al., 2019). The road was deliberately built at a higher elevation to avoid flooding and extend the life of the pavement, while the channels were placed at the lowest points as the main waterways. This arrangement reflects colonial design logic that not only prioritized technical efficiency, but also considered the sustainability of infrastructure in a wet tropical climate with high rainfall intensity. In principle, the system functions as an interconnected network, where irrigation, drainage, and road structures do not stand alone but are designed as an integrated system.

From a civil engineering and hydrology perspective, this construction demonstrates an engineering approach that relies on gravity, local materials, and human labor as the main sources of infrastructure production (Azis et al., 2021). There is no indication of the use of heavy machinery or complex mechanical systems, so the sustainability of water flow depends entirely on the geometry of the channels, the stability of the slopes, and the direction of flow. This approach reflects the low-maintenance engineering paradigm, namely technical systems that continue to function with minimal intervention from modern technology. In the colonial context, this type of irrigation system not only supported agricultural productivity, but also formed a spatial structure that was orderly and easily monitored by the colonial government.

The existence of these water channels shows how the colonists combined practical hydrological knowledge with landscape management to control water flow, support the agricultural sector, and protect roads from weather damage. This seemingly simple system is actually an adaptive technology that utilizes the mountainous topography and soil characteristics

to create an efficient, durable infrastructure network that is in harmony with the wet tropical conditions of Kerinci.

Archival photographs obtained from the KITLV collection show Dutch colonial officials inspecting infrastructure in Kerinci. The photograph shows a controleur standing with a number of local workers along a road and irrigation canal that are still under construction or undergoing routine inspection. The visual composition of the photograph shows the road and waterway structures running parallel in a single corridor, indicating that these two pieces of infrastructure were designed to be integrated. Technically, the canal visible at the bottom of the photograph shows a consistent cross-section, with relatively uniform width and depth, and lined with stones on both sides. This element serves as protection against erosion as well as a water flow regulator. Meanwhile, the position of the actors in the photograph indicates the working and power relations during the colonial period, where the colonial side acted as supervisors, while the local community acted as implementers. On the other hand, this photo is not only valuable as visual documentation, but also serves as material evidence of the application of civil engineering techniques, water management models, and colonial relations in the process of infrastructure construction in Kerinci.

In particular, the construction of colonial roads and irrigation channels brought significant changes to the Kerinci landscape. Gravity-based irrigation channels enabled the opening of terraced rice fields and the conversion of land that was previously forest, swamp, or unproductive land into managed agricultural areas (Tanesib et al., 2024). Colonial roads built parallel to irrigation networks served as the main transportation routes for the mobilization of agricultural products such as rice, coffee, and cinnamon. Over time, these infrastructure traces developed into settlement routes, markets, and local economic networks that have survived to this day. Ecologically, the use of stone embankments and drainage systems helped reduce the risk of erosion on vulnerable volcanic soil, although the expansion of rice fields and settlements caused changes to the natural water system and reduced the area of buffer vegetation. This transformation shows that the colonial legacy was not only physical, but also produced new social and ecological landscapes that still shape the spatial patterns of modern Kerinci.

The overall analysis shows that colonial infrastructure development in Kerinci was a combination of administrative needs, colonial strategy, and the application of hydrology-based technology and adaptive civil engineering. Roads and irrigation were designed not only as production facilities, but also as instruments of spatial control, economic integration, and landscape reorganization.

Environmental Impact of Colonial Infrastructure

The construction of roads and irrigation systems during the Dutch colonial period resulted in significant changes to the landscape of Kerinci. Irrigation channels designed based on gravitational hydrology enabled the planned opening of rice fields, including the formation of terraces and the

conversion of areas that were previously forests, swamps, or unproductive land into managed agricultural spaces (Tanesib et al., 2024). Meanwhile, colonial roads built parallel to irrigation networks served as the main distribution channels for agricultural commodities such as rice, coffee, and cinnamon, thereby strengthening the local economic structure and encouraging more intensive land use.

This transformation had a direct impact on the formation of spatial patterns in the region. The existence of roads and irrigation networks triggered the emergence of linear settlements, centers of economic activity, and market networks that developed along these transportation and irrigation corridors. From an ecological perspective, the construction of stone embankments and colonial drainage systems has been able to reduce the rate of erosion on vulnerable volcanic soils. However, the expansion of rice fields and settlements has also modified the natural water system, reduced the area of buffer vegetation, and altered the function of local ecosystems due to increased anthropogenic pressure.

Visual analysis of colonial photographs shows that these landscape changes involved socio-technical interactions between colonial officials as supervisors and local communities as implementers. These photographs are not only valuable as historical documentation, but also as material evidence of the application of civil engineering and water management principles that systematically shaped the spatial structure. This visual evidence is consistent with written archives and spatial data showing that colonial infrastructure development was carried out through planning that took into account land contours, water discharge, and environmental conditions, so that the system could function optimally even without modern technology.

In this way, colonial infrastructure in Kerinci not only formed a network of transportation and irrigation, but also acted as an agent of environmental engineering that reconstructed the landscape, influenced ecological dynamics, and shaped the spatial identity of the region in the long term. This infrastructure became an early example of planned environmental engineering that left ecological and spatial traces that can still be observed today.

IV. CONCLUSION

This study shows that the construction of colonial road infrastructure and irrigation systems in Kerinci was the result of a planned technical engineering process and did not stand as a mere physical project. Based on historical archives, colonial photographs, and old maps, it appears that the Dutch East Indies government designed this infrastructure to serve several purposes simultaneously: to strengthen administrative control, to facilitate the mobility of agricultural commodities, and to transform the landscape of the region into a more manageable space. The irrigation system, which was built parallel to the road, demonstrates the integration of transportation routes and water management, utilizing the principles of gravitational hydrology, hydraulic slope, and volcanic soil stability as the basis for its design.

Technical analysis of the shape of the channels, the selection of local materials, and the difference in elevation between the roads and water channels shows that the construction was based on a practical understanding of the characteristics of the tropical mountain environment. The colonial infrastructure was adaptive and served multiple functions: increasing agricultural productivity, controlling water flow, and protecting the road from erosion. These findings confirm that colonial technology not only represented economic and political interests but also reflected environmental engineering knowledge adapted to the geomorphology of Kerinci.

In addition to providing a technical overview of the colonial infrastructure system, this study reveals that road and irrigation development also drove spatial and ecological transformation. Gravity-based irrigation enabled the opening of terraced rice fields and land conversion, while the road network facilitated the growth of settlements and local economic integration. These impacts are still visible today, showing that the colonial legacy has shaped the Kerinci landscape in the long term and contributed to modern spatial patterns.

Thus, this study confirms that colonial infrastructure in Kerinci is not merely a historical relic, but a legacy of civil and hydrological engineering that is of great value for environmental studies, technological history, and landscape conservation. The multidisciplinary approach used in this study combining visual analysis, archival interpretation, and hydrological engineering principles provides a methodological contribution that can be used to study colonial infrastructure in other regions. Further research could focus on more in-depth spatial analysis, studies on the conservation of old infrastructure, and evaluations of the potential for revitalizing colonial irrigation networks in the context of modern water management.

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