

Forging Progress: Scientists and Engineers Shaping the Dutch East Indies Transformation, 1778-1942

Yon Machmudi¹, Abdurakhman¹, Wildan Insan Fauzi²✉

¹ Universitas Indonesia

² Universitas Pendidikan Indonesia, ✉ wildaninsanfauzi@upi.edu

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Abstract: European students started arriving in the Dutch East Indies in the 18th century. Later in the 20th century, the Dutch began implementing various technologies in irrigation, roads, railways, shipping, and industry. Colonial politics gave scientists and engineers an important and strategic place in the Dutch East Indies government. The central question guiding this research is, "What role did scientists and engineers play in the modernization of the Dutch East Indies from 1778 to 1942?". This historical research uses various archives at ANRI and newspapers from the colonial era to explore the role of scientists and engineers in developing science and technology and the transformation of the Dutch East Indies. The development of science and technology in the Dutch East Indies was intricately linked to Dutch colonial politics, disease outbreaks, capitalism's growth, and modernization. The findings of this research show the role of engineers in various projects for the construction of irrigation canals, ports, dams, roads, railways, trams, mines, telegraphs, airplanes, weapons, industry, and radio. These various projects impacted community mobility, city development, provision of clothing and food, employment opportunities, and other socio-economic impacts. Dutch scientists' activities initially had a limited impact on colonial society due to their elitist nature, lack of social support, bureaucratic obstacles, and entanglements in the political sphere. Dutch scientists have important positions in various research institutions, including botany, archaeology, physics, and the chemical industry.

Abstrak: Pelajar Eropa mulai berdatangan ke Hindia Belanda pada abad ke-18. Kemudian pada abad ke-20, Belanda mulai menerapkan berbagai teknologi di bidang irigasi, jalan raya, kereta api, pelayaran, dan industri. Politik kolonial memberikan kedudukan penting dan strategis bagi para ilmuwan dan insinyur dalam pemerintahan Hindia Belanda. Pertanyaan sentral yang memandu penelitian ini adalah, "Apa peran ilmuwan dan insinyur dalam modernisasi Hindia Belanda pada tahun 1778 hingga 1942?". Penelitian sejarah ini menggunakan berbagai arsip di ANRI dan surat kabar masa kolonial untuk menggali peran ilmuwan dan insinyur dalam pengembangan ilmu pengetahuan dan teknologi serta transformasi Hindia Belanda. Perkembangan ilmu pengetahuan dan teknologi di Hindia Belanda erat kaitannya dengan politik kolonial Belanda, wabah penyakit, pertumbuhan kapitalisme, dan modernisasi. Temuan penelitian ini menunjukkan peran insinyur dalam berbagai proyek pembangunan saluran irigasi, pelabuhan, bendungan, jalan raya, kereta api, trem, pertambangan, telegraf, pesawat terbang, senjata, industri, dan radio. Berbagai proyek tersebut berdampak pada mobilitas masyarakat, perkembangan kota, penyediaan sandang dan pangan, kesempatan kerja, dan dampak sosial ekonomi lainnya. Aktivitas ilmuwan Belanda pada awalnya berdampak terbatas pada masyarakat kolonial karena sifatnya yang elitis, kurangnya dukungan sosial, hambatan birokrasi, dan keterikatan dalam ranah politik. Ilmuwan Belanda mempunyai posisi penting di berbagai lembaga penelitian, termasuk botani, arkeologi, fisika, dan industri kimia.

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INTRODUCTION

Less attention has been given to writing on the history of science and technology in Indonesia, despite the significant impact of science and technology on society, as seen in various aspects of life (Fadeli, 2021). Many historians refrain from delving into this subject due to their limited knowledge of science and technology. Consequently, experts in the field primarily document the history of science and technology (Cihuy, 2019; Sahibudin, 2020). Science and technology serve as tools for fulfilling basic human needs such as food, mobility, communication, and defense and for enhancing the overall quality of life (Besari, 2008; Radhi, 2010). Technology plays a crucial role in generating and sustaining rapid economic growth, which is vital in improving the living standards of the Indonesian population (Rusdiana & Maesya, 2017; Wie, 2005).

In the 20th century, the Dutch initiated the application of various technologies in irrigation, road systems, railways, shipping, and industry, primarily to meet Dutch needs rather than to address the needs of the Indonesian people (Besari, 2018). The scientific, research, and technological institutions established during the colonial period that focused on botany, geology, zoology, and indigenous population studies served as a foundation for consolidating colonial power rather than fostering the prosperity of the local populace (Adam, 2009). However, according to Mrázek (2006), the concept of modernity in the Dutch East Indies differed somewhat from that in Europe, including the Netherlands. While European modernity transformed daily life through technology, in the modern Dutch East Indies, it was more directed towards appearance and entertainment, and the early 20th century marked a period of scientific advancement with the establishment of universities in the Dutch East Indies. Dr. Jan Willem Ijzerman had a pivotal role in this development by initiating the first engineering college in the Dutch East Indies (Mrazek, 2006). Notably, he served as the principal engineer of the Dutch railway service.

Scientists and engineers tried to carry out their social functions and roles to produce useful knowledge for the wider community. They believed that the science they developed would change colonial society and lead them to modernity (Goss, 2014). From a Dutch perspective, the scientific and technical knowledge developed in the Dutch East Indies created wide roads and employment opportunities, improved the population's welfare, and helped to provide food, clothing, and housing (*Bredasche Courant*, 1947). Apart from the epidem-

ic, developing science and technology in the Dutch East Indies was closely related to colonial politics and Dutch economic interests. Colonial politics intersected with Dutch scientists' interest in the natural conditions of Indonesia, which has a tropical climate rich in diversity of flora and fauna. However, for native intellectuals in the 1920s, it slowly became apparent that the government had never intended to provide access to the power of science. There were elements of racism and segregation in the creation of the scientific society in the Dutch East Indies. Forming the Batavian Community intellectual group was one way of establishing a dominant European culture in the Dutch East Indies (Besari, 2008).

This article discusses the role of Dutch scientists and engineers in transforming the Dutch East Indies towards modernization in the mid-19th to early 20th centuries. Andrew Goss, Holid, Kusdinar, Pieter Honig, and Verdoorn conducted many studies during the same period. Goss (2014) focuses on the relationship between scientists and the state from the VOC era to the end of the New Order. Goss's study mostly discusses scientists in the field of biology and touches little on other fields. This makes this article different from the study, which describes scientists and engineers in various fields. The study of scientists in various fields in the Dutch East Indies during the period was reviewed by Pieter Honig and Verdoorn (1945), but the description of the role of engineers needed to provide more space. Anwar Holid's study (2011) contains the development of Bio Farma for 100 years, from 1890-1990, regarding the development of *Parc Vaccinogen*, which was the forerunner of Bio Farma (1890-1942). The article, written by Kusdinar in 1988, contains statistical data on Bio Farma's success in tackling infectious diseases from the 19th to the 20th century. The book *History of Indonesian National Health* explains the history of health in Indonesia, especially since the collapse of the VOC until the 1970s (Ministry of Health, 1978).

Most of the latest research discusses the development of science and technology in post-independence Indonesia during the Old Order, New Order, and Reform periods. Raillon (1990) fully describes the development of Old Order and New Order policies in developing research and technology for industrialization and development. The studies of Aminullah (2007), Amir (2009), Hill (1995), and Moon (2020) both discuss the development of science and technology in Indonesia during the New Order period. However, Aminullah (2007) and Amir (2009) also discuss technological devel-

opments up to the reform era, especially until the early 2010s, while Hill (1995) and Moon (2020) focus on studying the New Order period 1966-1998.

METHOD

This research uses a historical method to describe events that occurred in the past. This is based on Gottschalk (1986), who stated that the historical method is the process of critically examining and analyzing records and relics of the past. Researchers chose the topic of the history of science with a focus on the efforts of Dutch scientists in building and developing science and technology through institutionalization (Sjamsuddin, 2007). Researchers visited several libraries and searched for archives related to the development of scientists and research and technology institutions during the Dutch East Indies. Libraries at various research and technology institutions (LAPAN, BATAN, MIPI, LIPI, and BPPT) as well as Bio Farma provide many sources in the form of documents on the development of various research and technology institutions during the Dutch Colonial government.

In the National Archives, documents from LAPAN, BATAN, MIPI, LIPI, and BPPT are available, including various documents issued by the Ministry of Research and Technology. In the national archives, a particular catalog is collected, and archives are grouped from ministries, including the Ministry of Health and the Ministry of Technology Research. Some archives are available digitally and can be downloaded on the ANRI website, including *National Creativity Series Archive Source Manuscripts* and *Public Health Series Archival Source Manuscripts*. This article also uses sources from newspapers such as: *Algemeen handelsblad voor Nederlandsch-Indië*, *Algemeen Dagblad*, *Algemeen Indisch dagblad*, *Bataviaasch nieuwsblad*, *Bredasche courant*, *De locomotief*, *De Indische courant*, *De Telegraaf*, *Het nieuws van den dag: kleine courant*, *Het nieuws van den dag voor Nederlandsch-Indië*, *Java-bode: nieuws, handels- en advertentieblad voor Nederlandsch-Indië*, *Nieuwsblad van het Noorden*, *Oprechte Haarlemsche Courant*, *Utrechts volksblad: sociaal-democratisch dagblad*, *Vooruit*, and *Zutphensch dagblad voor Achterhoek en Veluwezoom*.

The author makes notes about anything considered essential and relevant to the topics discovered while the research progresses, then critically evaluates all the evidence that has been collected. Criticism is an activity that assesses and analyzes the sources obtained by carrying out external and internal criticism. This activity aims to determine whether the collected sources are relevant to the

research to be carried out. This must be done so that the facts presented can be trusted. It is necessary to balance the sources issued by the Ministry of Research and Technology, BATAN, MIPI, and LIPI with external sources about scientific developments in the Dutch Colonial Period. This is also required to balance the narrative and also to arrange research results into a correct and meaningful pattern. In this step, the researcher carries out an interpretation, which is obtained from the results of thinking and understanding the information obtained from sources. The author then presents it in a way that attracts attention and communicates it to the reader so that it can be understood as clearly as possible. Historiography is the final stage in historical research, a writing activity, and compiling research results.

CATALYSTS OF CHANGE: ENGINEERS PIONEERING MODERNIZATION IN THE DUTCH EAST INDIES

European students began arriving in the Dutch East Indies in the 18th century to classify and organize the tropical world of Asia, especially after most of the region fell under colonial rule. They first studied their colleagues' explorations before coming to the colony. This group of scientists created learned societies in the colonies and became amateur researchers before finally being replaced by scientific institutions at the end of the 19th century. In the 19th century, several large technological systems were introduced, which significantly impacted the social development of the native people of the Dutch East Indies, especially on the island of Java. *De Groote Postweg* and communications, *cultuurstelsel* and irrigation, and railway systems are among the most important. Most of the technologies introduced by the VOC and the Dutch East Indies government could not provide additional value to the people of the archipelago (Besari, 2008).

Entering the early 20th century, engineers in the Dutch East Indies covered various technological fields. Dutch engineers actively developed infrastructure in the Netherlands and the Dutch East Indies. Entering the 20th century, these engineers began to organize themselves. In April 1912, the organization of water engineers (*waterstaat ingenieurs*) was established (*Bataviaasch nieuwsblad*, 1912), followed by the organization of mining engineers (*mijn ingenieurs*) in 1919. The next development, the *Technische Hoogeschool*, which produced engineers in various scientific disciplines, was established in Bandung in 1920. The *waterstaat ingenieurs* organization regularly held meetings, one of

which was in Surabaya in December 1924 (*Algemeen handelsblad voor Nederlandsch-Indië*, 1924). One of the heads of the *Waterstaat Ingenieurs*, E. J. Uilkens, played a major role in creating the city of Batavia in 1937 (*De locomotief*, 1937).

Development of Irrigation, Waterworks, Fisheries and Maritime Affairs

In 1832, the Dutch began a project to create irrigation routes on indigenous farms and plantations, including those owned by the government, through the *Burgerlijke openbare Werken* (BOW) for the benefit of cultivation. Dutch experts at the *Technische Hogeschool* in Bandung, such as D.G. Romijn and H. Vlugter, studied various research to develop irrigation for agriculture and plantations. Cornelis Lely and Prof. Van Breen were engineers with expertise in irrigation (*De Indische Courant*, 1922). Van Breen was also involved in the canal-building project in Batavia to prevent flooding (*Het nieuws van den dag voor Nederlandsch-Indië*, 1919). Ir. Raedt van Oldenbarnevelt was a water engineer in Padang before 1940 (*Zutphensch dagblad voor Achterhoek en Veluwezoom*, 1949).

Van Thiel started a dam construction project even though it failed several times due to being swept away by floods. Only at the end of the 19th century was the dam successfully built by paying attention to and studying rivers characterized by a tropical climate (Besari, 2008). One of the hydropower development engineers in West Java was Ir. Van Staalén (*Algemeen Dagblad*, 1953). B. J. Dageis was an agricultural engineer who came to the Dutch East Indies in 1918 and spent quite a lot of time in Sumatra and Kalimantan as an agricultural inspector from 1930-1946 (*De Telegraaf*, 1959).

In 1832, the Colonial Government repaired the Kali Sampean dam in East Java, which the people had initially built (Besari, 2008). Since then, there have been three types of rice cultures in the archipelago: some that receive water from the BOW irrigation system, some from the people's irrigation system (non-technical), and others that are rain-fed rice fields. D.G. Romijn and H. Vlugter studied the hydraulics of spillways (*overlaat, wiers*). Another essential scientific development was in structural mechanics and materials science carried out by P.P. Bijlaard, also at *Technische Hogeschool*, Bandung. The person concerned researched steel structures' instability and elastoplastic behavior (Besari, 2008).

Entering the 20th century, the amount of water flowing into various irrigation canals was measured using various measuring instruments, either in

the form of screens from Thomson, Cipoletti or in the form of spillways from Rehbock, Romijn, Vlugter, and so on. This way, the right amount of water can be given to an irrigation area according to its area and season (Besari, 2008). The area of rice fields that received irrigation engineering had reached a total of 1,768,000 shoulders or 1,237,000 ha, covering more than 23 areas throughout Java. However, towards the 20th century, the irrigation system in the Dutch East Indies began to become a wholly scientific and engineering-based technology (Besari, 2008).

In fisheries and marine affairs, Darwin (1842) and Molengraaff (1929) began researching coral reefs and their distribution in Indonesia. Since 1888, many fish taxonomists from the Netherlands have worked in Indonesia, such as Max Weber, de Beaufort, and Pieter Bleeker. H.C. Delsman and J.D.F. Hardenberg were the most important among them. Hardenberg increased his knowledge of Indonesian fish fauna through his 1937 review entitled *Marine Biological Research in the Dutch East Indies in the Last Three Decades* (Soegiarto, 1975).

Architects of Urban Transformation: Engineers Shaping Modernity in the Dutch East Indies

Cities in the Dutch East Indies, such as Batavia, Bandung, Semarang, and Surabaya, proliferated in the early decades of the 20th century. The growth of these cities was in line with the development of urban planning science and technology, architecture and city planning, water distribution, sanitation and waste processing, and clean water distribution (Mrazek, 2006). Famous Dutch architects include Maclaine Pont, Wolf Schoemaker, Cuypers, de Vistarini, and H.P. Berlage. At the same time, competent native architects such as Soesilo emerged. With their various schools of thought, these Dutch architects tried to bring "Europe" to the Dutch East Indies with various urban planning designs and buildings. The city's growth was followed by the development of energy technology, especially electricity. Data shows that in 1930, only 9% of Java had electricity. Electricity was so expensive that the native population could not afford it.

City growth was related to city infrastructure development, including the emergence of buildings and housing. Maclaine Pont was an architect who built various buildings in the Eurasian style, including the ITB building. C.P. Wolff Schoemaker was a famous artist and teacher at ITB (the teacher of Soekarno, President of the Republic of Indonesia). He designed the *Preanger Hotel*, *Concordia*, and *Villa Isola*. Architect thinkers in the 1930s who crit-

icized many development patterns in the Dutch East Indies then were Eduard Cuypers, B. De Vistarini, and Willem Walaven (Mrázek, 2006). There were significant changes in house construction and architecture generally in the early 20th century, especially changes in the views of the Dutch themselves. Before the 20th century, the Dutch felt that they were only staying temporarily, and they lived in a country surrounded by “enemies” in colonial countries, which impacted the results of buildings that were far from perfect and seemed closed. It was not suitable for tropical environments that require good air circulation. This view changed in the 20th century, and they felt confident they would stay in this colony long. Pieter Adriaan Jacobus Moojen was an architect who had played a role in developing the city of Bandung (West Java) since 1904. Moojen was assigned to Bali when an earthquake damaged the island on January 21, 1917. The government assigned Moojen to investigate the effects of the disaster and record the condition of several destructions of buildings, houses, temples and public buildings (*Algemeen Indisch dagblad*, 1955).

Development in the Field of Communication and Transportation Technology

The train line brought major changes in the population’s economy, the development of Java, and accelerated transportation of basic materials and products (*De Telegraaf*, 1898). In 1869, horse trams, which moved on rails, were built in Batavia. The first railway line, the Semarang-Surakarta-Yogyakarta line, was built in 1862 by the *Nederlandsch Indische Spoorweg Maatschappij* (NIS) company. Simultaneously, the Batavia-Buitenzorgh line was also built with this project. J.P. de Bordes was the engineer who supervised the two railway line projects (Besari, 2008). Most workers making the train line were native residents, and a small number were graduates of the *Delft Polytechnic* (Netherlands). Since then, the Dutch colonial government has continued constructing railway lines in Java and Sumatra. In Sumatra, railway projects were developed by the Railway Bureau engineer Willem Ijzerman, who in 1924 initiated the construction of a Technical School in Bandung (Mrázek, 2006). Dutch engineers who played a role in the development of the railroad included Rietsema van Eck and Plate, J. A. Kool, J. Witsen Elias, and M. Simon (*Opregte Haarlemsche Courant*, 1860).

Since mid-1878, the railway line was built in stages from Bogor to Cilacap through the inland

area of Priangan. In terms of transportation itself, trains in the Priangan area operated in stages from 1881 to 1911 (Lubis, 1987). One thousand eight hundred eighty-eight train lines in Java were operating, connecting 15 major cities. Apart from train lines, since 1899, electric trams began to be built in Batavia and grew to 14 km in 1909. In 1918, the skilled workforce at the Dutch railway company was dominated by Dutch, ethnic Chinese, and European-Indigenous descent (Mrázek, 2006). In 1880, J.F.F. Moet asked the Dutch government to help build roads and railway lines. The discovery of machines that gave birth to two- and four-wheeled vehicles also encouraged the colonial government to develop road transportation further. The Post highway that Daendels built was too congested and dirty, so another road needed to be built (Mrázek, 2006).

In the Dutch East Indies, wooden ships had been replaced by steel-hulled ships, and machines had replaced sails. Jayakarta Harbor (Fish Market) no longer met steamship requirements so Tanjung Priok was excavated in 1877 to be built as the first ocean port in a system consisting of many ports in the Dutch East Indies. Thus, modern shipping and sea transportation system technology had been introduced in the Dutch East Indies (Besari, 2008). Delft engineers created a seaport in the Dutch East Indies with the construction of Tandjong Priok in 1880 (*Vooruit*, 1942). Modern, hygienic villages that provided housing for many port workers and their families were built during the construction of the port.

The new technologies introduced by the Colonial Government to the Dutch East Indies at the beginning of the 20th century - still in the field of transportation - were motorbikes, cars, and airplanes. The *Koninklijke Nederlandsch Indische Luchtvaart Maatschappij* (KNILM) aviation company was founded to provide air transportation services in the Dutch East Indies. Ir. P.C.J. Vos, who worked at *Koninklijke Paketvaart Maatschappij* from 1927 to 1935, played a major role in developing the aircraft industry in the Dutch East Indies (*Java-bode*, 1953). The Dutch Fokker Company assessed that in 1940, establishing an aircraft factory would not be possible for the time being (*Utrechts volksblad*, 1940). The pioneer of aviation in the Dutch East Indies was Ir. G. P. Ilmuer; he made a flying demonstration in the Dutch East Indies in 1911 (*Nieuwsblad van het Noorden*, 1959). Air flights in 1928 were already busy; most were tourist flights for Europeans but did not touch indigenous interests (Mrázek, 2006). Dutch pharmacist H.F.

Tillema widely promoted the importance of paved roads and clean water.

In 1856, the Dutch East Indies Government opened a telegraph line between Batavia (Jakarta) and Buitenzorg (Bogor). Moreover, the following year, the Batavia-Surabaya telegraph network was opened. The development continued to reach Sumatra and Singapore, as well as the entire islands of Java, Bali, Lombok, and Sulawesi (Besari, 2008). In 1900, telephone networks were established in Batavia, Cirebon, Tegal, Pekalongan, Semarang, and Surakarta (Mrazek, 2006). That year, there were 925 telephone subscribers in Batavia, 371 in Semarang, 568 in Surabaya, and 123 in Yogyakarta. Radio had been developing rapidly since 1918, starting with creating a radio station in Malabar Hill, Bandung. Thus, the Dutch East Indies radio transmitting station ANETA was born. ANETA broadcasts spread to Bandung, Yogyakarta, Semarang, Surabaya, Makassar, Manado, and other big cities in Indonesia (Mrazek, 2006). Regular broadcasts appeared in 1933 via *Philips Omroep Holand Indie and Nederlandsch Indische Radio Omroep Min* (NIROM). This radio increased consumerism among the people of the Indies, especially the European population, because of the large number of commercial advertisements on the radio. The Netherlands prohibited political and religious propaganda in radio broadcasts. G.A. van Bovene was a figure who rose to fame along with the development of media culture, which was born from radio.

Development of the Chemical, Textile, and Mining Industries

The establishment of the first cement factory in Indarung in 1910 marked the start of the chemical industry in the Dutch East Indies. The Dutch also established paper factories in Padalarang and Leces. Daalenoord was a scientist who succeeded in making the TIB *Getouw loom* machine in 1922. The loom he created was distributed throughout the archipelago from 1930 to 1937 and helped to develop the textile industry in the Dutch East Indies. The machinery industry in the Dutch East Indies began with the founding of N.V. de Bromo in Pasuruan (1865), N.V. De Industrie (1878), and CV Vulkaan (1918) in Surabaya. This industry was established to repair and supply machines for processing plantation products (Sudariyanto (ed), 1992).

Mining exploration in the Dutch East Indies in the 19th century was somewhat hampered because the country lacked capital (*Het nieuws van den dag: kleine courant*, 1896). In 1823, the Colonial Government took over tin mining in Bangka. Prins

Hendrik der Nederlanden and Baron Tuyll van Serooskerken received concessions for the added tin (Besari, 2008). The discovery of coal fields in 1868 in Oembilin by Dutch mining expert W.H. de Greve encouraged many expeditions to discover metal and other mineral mines (Mrázek, 2006). Since 1881, oil and gas exploitation has helped to encourage the development of mining technology in the Dutch East Indies. P.P. Bijlaard is internationally renowned for his studies on steel structures, which became the basis for developing the science of materials mechanics (Besari, 2008).

Junghuhn explored the archipelago from 1840 to 1864, researching the geology and mineral resources. At the beginning of the 20th century, the Dutch founded the *Dienst vat het mijnbouw Mining Institute*, which consisted of experts from the Netherlands, such as Cloos, van Bemmelen, Kuenen, and Umbgrove. Their research succeeded in revealing the geological structure as well as the secrets of Indonesia's mineral wealth. It became a model underlying the theory of mountain and volcano formation (Sudariyanto (ed), 1992). Meinesz's research (1927-1930) was the key to the theory of plate shift. The history of science and scientists in the Dutch East Indies would only be complete with the story of Vening Meinesz's exploration with the extraordinary cooperation of the Dutch Navy (Field, 1945). In connection with tropical climate studies, Van Bemmelen built a system of secondary meteorological stations spread throughout the archipelago, with altitudes ranging from sea level to a height of 3000 meters on Mount Pangerango. Forty-two of them were in operation in 1918 (Braak, 1945).

In 1823, tin mining became a company owned by the Colonial Government, becoming a kind of BUMN, which collaborated with Chinese kongsi (companies) in Bangka. In 1852, Prins Hendrik der Nederlanden and Baron Tuyll van Serooskerken received a concession for exploiting tin mines. The concession was then delegated to *Billiton-Maatschappij* in 1860 and extended in 1892 (Besari, 2008). The Dutch petroleum company *Koninklijk Bataafsche Petroleum Maatschappij* (BPM), founded in 1886, later became a multinational company (Besari, 2008). Then, the company and other foreign-owned petroleum companies exploited Pangkalan Brandan, North Sumatra, East Java, South Sumatra, Riau, East Kalimantan (Tarakan), and others. Coal mines in Bukit Asam and Muara Enim had also been exploited. Subsequently, the Phillips electrical and electronics manufacturing company and the machinery industry were also

founded, which provided services for maintaining machinery from various industries in the Dutch East Indies, such as sugar factories, shipping, and others (Besari, 2008). Ir. De Kock was an engineer at *Bataafse Petroleum Maatschappij* who played a major role in developing and exploiting Petroleum in the Dutch East Indies (Vooruit, 1940).

TRAILBLAZERS OF PROGRESS: SCIENTISTS DRIVING THE MODERNIZATION OF THE DUTCH EAST INDIES

In the 18th century, Batavia, a Dutch intellectual society, consisted of some university graduates, many who had legal education and were lawyers, some academically trained doctors (doctors were surgeons), and most botanists (Groot, 2009). In the 19th and 20th centuries, international scientists and experts from various countries visited the Dutch East Indies, especially in medicine, applied geology, and agriculture. Figures such as Willem Ijzerman, Alfred Russel Wallace, Franz Wilhelm Junghuhn, and Christiaan Eijkman emerged and later were recognized as superior scientists. The colonial government employed German forestry experts who mastered scientific forestry techniques to expand state control over the forests in Java by designing various legal and bureaucratic mechanisms. The activities of these “apostles of enlightenment” did not have much impact on colonial society because of their elitist nature, lack of strong social support, and obstacles from colonial government bureaucracy. These scientists also preferred to pursue a political career (Goss, 2014).

Scientists Leading Botany Research and Development in the Dutch East Indies

Systematic botanical research resulted in the twelve volumes of *Hortus Indicus Malabaricus* (1678-1693) by Hendrik Adriaan van Reede tot Drakestein and *Amboinsche Kruidboek* (1741) by Georg Everard Rumpf (Rumphius). On the other hand, research in the Dutch East Indies was also intended to benefit the botany professor at Leiden University. Other practical sciences practiced were the arts of navigation, astronomy, and geography, all aimed at increasing the knowledge necessary for successful travel (Groot, 2009). In the seventeenth century, the VOC needed painters and drafters for topographic paintings, city landscapes, marine paintings, and portraits.

Since 1840, 11 journals regarding Indonesian ecology have been published in Batavia. In 1842, Franz Junghuhn began collecting data regarding geographical and natural changes in the Dutch East

Indies islands. Within 1835-1848, Junghuhn explored volcanoes in Java, and his research was published in the book *Java, Vessels, Gedaante, Bleeding, En Inwendige Structuur* (Java: Form, vegetation, and internal structure). The British scientist Alfred Wallace also carried out this study, who traveled around the archipelago from 1854 to 1862 to explore flora and fauna distribution patterns.

Knowledge of botany developed in the Dutch East Indies with the existence of the Bogor Botanical Gardens. Blume and P.F. von Siebold were some of the leading scientists. Blume headed the *Rijksherbarium Botany* from the Netherlands, and Siebold was an *Irish* (Japanese) flower cultivation expert. Then, in 1817, C.G.L. Reinwardt founded the “Indonesian Botanical Garden” in Bogor. Since 1840, the Bogor Botanical Gardens (Buintenzorg) management has been in the hands of the governor-general. This was related to the funding for managing the botanical gardens, which was quite large. Among the scientists born from the *Bogor Botanical Gardens* were J.E. Teysmann and J.K Hasskarl, who connected the *Bogor Botanical Gardens* to the international network of botanists.

In 1844, with the support of the colonial government, the *Bogor Botanical Gardens* succeeded in creating a catalog, herbarium, and library. Unfortunately, subsequent governors-general were not too interested in botanical gardens as centers for the development of botanical science, which also impacted the funding. Melchior Treub (who came to the Dutch East Indies in 1880) tried again to advance the *Bogor Botanical Gardens*, attempted to make it a center for agricultural research, and internationalize botanical research in the Dutch East Indies. Under his leadership, the *Bogor Botanical Gardens* were staffed by 46 visiting scientists of Dutch and German nationality. Melchior Treub also researched Mount Krakatau, taking soil and plant samples and analyzing them in Buitenzorg (Bogor) (Mrázek, 2006).

Apart from the *Bogor Botanical Gardens*, there is also the *Cibodas Botanical Garden*, built around 1852. In 1856, Teuscher was recorded as the administrator of the botanical garden. Teysmann began planting Quinine in the *Cibodas botanical garden* in 1852. J.K Hasskarl received an assignment from the Dutch East Indies government (Pahud) in 1851 to acclimatize Quinine. The idea of introducing Quinine to the island of Java had been previously conveyed by several experts such as Reinwardt, Blume (1929), Fritze, Mulder (1838), Vrolik (1839), Miquel (1846), Fromberg and Junghuhn to the Dutch government (Soerohaldoko et al., 2006). A

detailed history of quinine cultivation in the Dutch East Indies was contained in the official report of the Department of Agriculture (*Officieele Landbouwkundige Verslagen*) and notes in the *Java Courant* about the development of Quinine in Java from 1856 to the beginning of the 20th century (Honig & Verdon, 1945).

In 1854, Hasskarl succeeded in planting cinchona trees in the *Cibodas Botanical Gardens*, West Java. Hasskarl added other types of quinine, namely *C. Pahudiana*, in 1854. Junghuhn and J.E. de Vrij continued their efforts in 1856-1863 but failed. F. Junghuhn was ordered to take over Hasskarl's work and continue it (Gorkom, 1945). J.E. Teysmann criticized Junghuhn's scientific efforts, but the colonial bureaucracy meant that Teysmann could not do anything. Junghuhn also criticized the protection of quinine acclimatization in Cibodas because it would damage local vegetation and possibly cause new pests to emerge. Junghuhn moved the quinine cultivation project from Cibodas to Pangalengan in 1856. His project was then continued by van Gorkom and Moens in 1864, and they succeeded in acclimatizing quinine. Gorkom's findings succeeded in uniting the desires of the colonial bureaucracy, capitalists, and scientists' interests. In 1880, Javanese *Kina* dominated the market and provided enormous profits for entrepreneurs, including the Dutch colonial government.

JHF Solleijn Gelpke was a Dutch official assigned to cultivate rice in 19th-century Indonesia. The biggest obstacle to rice cultivation in the Dutch East Indies was that some superstitious beliefs were still attached to rice cultivation (Sudariyanto, 1992). The Dutch government began implementing agricultural mechanization in 1914 on sugar cane plantations in Sidoarjo. In 1857, W.H. de Vriese researched agricultural conditions in the Dutch East Indies for three years. The results of his research contained a request that changes in agricultural governance in the colonies should be based on scientific foundations. The Dutch colonial government rejected this proposal. Governor General Pahud controlled Vriese's research and directed it to his interests (Goss, 2014).

Melchior Treub led the *Cibodas Botanical Gardens* from 1880-1905, a branch of the *Bogor Botanical Gardens*. Treub began to increase research facilities and infrastructure in Cibodas by building a foreman's house (1890), a guest house for migrant research, and a scientific laboratory in 1891. A researcher at the *Cibodas Botanical Gardens*, Dr. J.M. Jense, researched *mycorrhiza* and wrote many papers about it from 1890 to 1897. Research on forests

carried out by Koonders and J.G Boerlage succeeded in creating a catalog of the *Cibodas botanical* forest collection. Melchior Treub in 1882 sent Burck on a botanical expedition to Sumatra. Boerlage went on an expedition to Maluku and died on his way back to Java in 1899. In 1894, Treub founded the Museum of Zoology and Plant Pathology, which researched agricultural pest insects (Goss, 2014). Treub tried to convince plantation entrepreneurs to help fund the research. Treub continued to add equipment and facilities for biological research at the *Cibodas Botanical Gardens* to the top of Mount Gede in 1891 (Soerohaldoko et al., 2006).

Another effort undertaken by Treub was to build an agricultural school for the native population to form native administrators who were scientifically educated and acted as intermediaries between European and native rulers (Goss, 2014). The school was opened in 1903 with the help of Abendanon (Director of the Ministry of Education, Religion and Industry). Treub played a significant role in establishing the Ministry of Agriculture, which began working on January 1, 1905. Agricultural colleges were restarted in 1903, and by 1915, there were eight agricultural schools in Java. Botanical scientists actively researched the *Cibodas Botanical Gardens* in the early 20th century, including Koningsberger, Cosquino De Bussy, Jansen, Fafe Went, and Fritz Went. They managed to raise funds, which saved the *Cibodas Botanical Gardens*, which experienced a financial crisis in the 1930s.

Dr. Tolenaar started conducting radiation research in the Dutch East Indies to obtain new types of plants (tobacco) in 1934 in Central Java (Sudariyanto (ed), 1992). Thomas Horsfield (1773-1859) was a US physicist who visited Batavia in 1800. Horsfield was appointed chief surgeon in the government service in 1802 to research native herbs and plants. During his years researching in the Dutch East Indies, Horsfield developed from a doctor to a botanist, zoologist, and geologist. During those eight years, he regularly reported to the *Bataviaasch Genotschap van Wetenschappen* and the government, as seen from the 1812 notes he compiled for Raffles (Sutanto, 1977). In 1805-1806, Horsfield sent a copy of herbal medicine to the association and reported in March 1806 about its progress from East Java.

Scientists' Contribution to Health Development in the Dutch East Indies

The development of science and technology in the Dutch East Indies was also related to the arrival of disease outbreaks. Cases of smallpox in Java were

discovered in the early 17th century (Reid, 1988). In 1780, variolization was introduced in Batavia to prevent smallpox, although it was temporarily limited in scope. Smallpox killed many people (Loedin, 2005). In 1781, it was estimated that out of 100 Javanese people who were attacked by smallpox, 20 of them died (Baha'uddin, 2006). This disease appeared between 1775 and 1815 in Java, Priangan, Yogyakarta, and Surakarta coastal cities. Meanwhile, in 1786, smallpox was already known to exist in the Banten and Lampung regions (Baha'uddin, 2006). Between 1775 and 1815, smallpox spread in several large cities in Java, including Bogor, Priangan, Yogyakarta, and Surakarta (Boomgaard, 2003). In 1871, there was a smallpox epidemic in Bali that killed 18,000 people (Holid, 2011).

In 1804, the Dutch East Indies Government began issuing the first Government Regulation regarding smallpox vaccination, *Resolutie, Vrijdag*, on 21 September 1804. At that time, smallpox vaccine began to be imported from Europe to Batavia to provide widespread vaccination. The imported vaccine resulted from the development of Edward Jenner, a British health researcher. The smallpox vaccine was carried by children by vaccinating each other during the journey, ensuring that smallpox seeds remained alive (Loedin, 2005).

In 1820, the Civil Health Service (*Burgerlijke Geneeskundige Diensten*) issued a Civil Health Service Regulation (*Reglement voor den Burgerlijke Geneeskundige Diensten*) which coincided with the issuance of the Smallpox Vaccination Implementation Regulation (*Reglement op de uitoefening der koepokvaccinatie in Nederlandsch-Indie*), which, among other things, determined: The entire vaccination effort is placed under one inspector; In each residency, a supervisor (*opziener*) is appointed, at least a local doctor; Supervisors must provide vaccinations every week in their workplace and surrounding areas.

Christiaan Eijkman researched *beri-beri* disease that attacked workers in forced labor camps in the Dutch East Indies. Eijkman became director of bacteriology at STOVIA and discovered that germs did not cause *beri-beri* but lacked a substance in food (vitamin B) (Holid, 2011). In 1888, *the Pathological Anatomy and Bacteriology Research Laboratory* was established in Batavia, and Christiaan Eijkman became its director. Gerrit Grijns continued Eijkman's study, finding that *beri-beri* occurs due to a thiamine deficiency (Vitamin B Complex). Eijkman and Gowland Hopkins (England) received the Nobel Prize in Medicine in 1929. In animal vaccination, Dr. W.J.J. Zuur was one of the ex-

perts in processing vaccines for animals around 1879-1880. Schunckink Kool (first director of *Parc-Vaccinogene*), in 1884, succeeded in making a vaccine using cows as a breeding ground. Schunckink's research was continued by Eilerts de Haan, who researched vaccines for rabies. In 1910, Anton Nijland succeeded in finding a cholera vaccine. Nijland contributed to the development of the Pasteur Institute and *Koepokinrichting*. The dry smallpox vaccine was discovered by Dr. Otten, who succeeded in pioneering research in clinical biochemistry during his career. To this day, a vaccine made by Dr. Otten is routinely given to Hajj pilgrims who are leaving for Mecca.

Scientists' Contribution to Geography, Astronomy, and The Environment

In the interest of institutionalizing science in the Dutch East Indies, in 1848, Van Hoevel held a meeting in Batavia, which gave birth to the idea of the importance of research in the fields of geography, society, and the environment to help build political order in colonial countries (Goss, 2014). A follow-up to the meeting was an exhibition of naturalist research results held in 1853 in Batavia. *Natuurkundige Vereeniging* designed the exhibition in *Nedlandsch Indie* (Netherlands Indian Naturalists Association). The group was led by Piet Bleeker, a friend of Junghuhn's, and since the 1840s, has succeeded in keeping a journal on natural history.

R.A. Van Sandick published a book about the eruption of Mount Krakatau (1883) in 1890. The book was a valuable contribution to the development of geology. Another geographer was J.A.C. Oudemans, who worked in the Dutch East Indies from 1857 to 1890 as "Chief Engineer of the Geography Service." Prof. Stokvis is one of the experts who had researched colonial society in the Dutch East Indies, especially the situation of Dutch people in the colonial countries (Mrazek, 2006). Jean Abraham Cretien who became the Chief Engineer of the Geography Service in the Dutch East Indies in charge of mapping the Dutch Indies through astronomy (Mrázek, 2006). Cretien's father, Oudemans, noticed that the meters used in Java were not calibrated with those in Paris and were not corrected for temperature variations. In 1894, he obtained a new meter that was calibrated.

Research in the field of astronomy has developed rapidly since the opening of the Boscha observatory in Lembang on October 29, 1923. Boscha was the son of a physicist who graduated from the Delft Higher Technical School (Netherlands). Until World War II, research at Boscha was carried out

by Dutch people, one of whom was J.G.E.G Voute and Prof. Pannekoek. Pannekoek carried out in-depth research on the Milky Way galaxy. Other researchers from Boscha are Paul Ten Brugercate (Germany) and Wallenquist (Sweden). Research at the Bosscha Observatory has produced various scientific works that are very important for future astronomy development. Some of these are the works by J.G.E.G. Voute, who made photographic observations of visible double stars (visual double stars). This research produced work that later became the basis for the astrometric determination of binary stars near the sun. Then, Pannekoek created a work of 'isophote brightness lines' on the southern side of the Milky Way. This work later became the basis of the section of the Milky Way known as the Skalnate Pleso Atlas and was an essential tool for determining galactic structure. There are many more research results and studies carried out by the Bosscha Observatory, including those by Dr. Paul ten Bruggencate from Gottingen, Germany, and Dr. Wallenquist from Uppsala, Sweden. Interested readers can refer to the various available works (Besari, 2008).

The Physics Commission of the Dutch East Indies was established in 1820. The research assigned to Reinwardt was given a permanent character by establishing the Physics Commission. The Physics Committee for the Dutch East Indies, founded in 1820 to give a great impetus to research the nature of the Dutch East Indies, also put together a collection for the homeland. Dr. Tolenaar started conducting radiation research in the Dutch East Indies to obtain new types of plants (tobacco) in 1934 in Central Java (Sudariyanto (ed), 1992).

CONCLUSION

The research results show that the development of science in Indonesia is institutionally based due to the absence of modern scientific culture in Indonesian society and the Dutch scientific elite's monopoly of research and technology. The early scientists from the Netherlands who came to the Dutch East Indies felt that they had a role in the "enlightenment" mission of the native population and were interested in the natural conditions of Indonesia, which had a tropical climate that was rich in diversity of flora and fauna. The development of science and technology in the Dutch East Indies was closely related to Dutch colonial politics, the arrival of disease outbreaks, and the need for modernization. The activities of these "apostles of enlightenment" did not have much impact on colonial society because of their elitist nature, lack of

strong social support, and obstacles from the colonial government bureaucracy, and these scientists preferred to pursue a career in politics.

These Dutch scientists and engineers worked for both the government and private companies. They have technocracy ideals, trying to make science and technology play a big role in the transformation of society. In some ways, the aims of the technocracy were supported by the colonial government and in line with colonial politics. However, it made them part of the colonial government bureaucracy. On the other hand, colonial politics made their position important and strategic because the Dutch needed their expertise in various strategic projects and to run various research institutions. Engineers who graduated from the Delft Polytechnic played an important role in constructing various infrastructures in the Dutch East Indies, such as railways, bridges, ports, irrigation canals, dams, and even the development of the commercial aircraft business. Dutch scientists have important positions in various research institutions, including botany, archaeology, physics, and the chemical industry.

This article focuses on descriptions of Dutch scientists and engineers who played a role in transforming the Dutch East Indies towards modernization and does not discuss indigenous scientists who had a role in developing science in the Dutch Indies. However, some historians consider the involvement and role of indigenous scientists to be almost invisible. Honig & Verdoorn's article entitled Science and Scientists in the Netherlands Indies states that more than 20 indigenous scientists worked in Dutch research stations. This is an opportunity and recommendation for other researchers to conduct research regarding their role in advancing science during the Dutch East Indies.

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