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Science and Technology Development in Dutch East Indies

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Abstract

This article describes the long history of the development of science and technology in Indonesia under Dutch East Indies Administration. This study views at how education and science and technology policies in together create the development of the contributions of researcher in research institutions. The study uses a convergent model triangulation which is a mixed method in which the qualitative use the archive to find comprehensive traces taken through written sources, quantitative method and bibliometric to show how research networks are formed in producing research from 1849 until 1940, especially on research topics. This study collects data from 201 scientific articles from Scopus database to obtain information about the trends of Dutch East Indies scientific publication. The findings of this study are after ethical politics in the beginning of 21 century, colonial government failed to provide more inclusive education system for all groups. Therefore, the scientist who contributed are mainly from European group and small contribution of Indonesian in the medical field. In the national context, there were an incline number of scientific publications after 1920s that is contributed from the established a wide range of government research and development institutions the decades before. After the colonial government ended in 1941, these advantages became the initial foundation of science and technolgy ecosystem in Republic of Indonesian Government.

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Introduction

The development of science and technology (S&T) in Indonesia cannot be separated from the influence of Dutch colonialism which established the initial foundation for the S&T ecosystem under the administration of Dutch East Indies. During the governance period until 1941, S&T infrastructure was made, especially educational and research and development (R&D) centers that supported the affairs of the colonial government. The development of human resources and its policies on the development of educational institutions is carried out where after ethical politics that allows more extensive education at all levels of society, including Indonesian groups.

The number of studies that describe the long history of the development of Indonesian S&T during the Dutch colonial period is still scarce. Some scholars focus on the development of S&T from the point of view of education, especially post-ethical politics. Fakhriansyah & Patoni (2019) studies the access of indigenous society to the dutch education system that they argue there were the barrier of indigenous society to

access freedomly. This is caused by the political system in Dutch East Indies that produce 'elite' education. Laely (2018) describe the elite education provides education with dutch as intermediate language so that there were no well education that is provided in indigenous language. While other opinion, Suratminto (2013) argues that education policy is tend to be discriminated to indigenous society because the dutch government set the indigenous society to contribute in low-skilled labour in the country development.

Meanwhile, some studies describe the role of researchers and their organizations to develop and advance knowledge under the Dutch East Indies Government. Gross (2011) writes how the natural researcher in Dutch East Indies was diverted by colonialism interest. The researcher that should brings the advance of S&T as main principle changed to how S&T can contribute to colonial advantage. Even though, Hesselink (2019) argues that in the period after 1900s, there were the signifficant number of journal articles in the medical area that directly support both the advantage of colonial interest and the development of S&T.

However, research that discusses the relationship between both the education system and its contribution to the development of S&T is still new, especially the role of Indonesian researchers. Therefore, this study will fill the gap through answer several important questions which are 1) How were the Dutch East Indies education policy produce an inclusive education system 2) How was the dynamics of the role of researchers in developing S&T under the government of Dutch East Indies 3) What was the role universities and R&D in creating the advance of national S&T development.

At first, this research will specifically examine how the social and economic factors of the Dutch East Indies community influenced policies in building an education system for its people. This education system will produce human resources that can become scientists to create knowledge. This supply will meet the demands of S&T and become the mainstay of the government to steer national knowledge development. At this point, this paper will also focus on the role of Indonesian researchers in producing a research product. In the end, this research will answer the role and trend of science and technology development through the mapping of scientific publications from research organizations both under the government and independent scientific organizations.

Method

As part of historical research, a basic process is carried out to achieve an accurate point of view of the phenomenon from the process of collecting historical facts (heuristics), source of criticism, interpretation, and historiography (Alian, 2012; Garraghan, 1957; Sukmana, 2021; Wasino & Hartatik, 2018). The heuristic process that demands the construction of events in the past based on a constructivist point of view that views a historical event as influenced by various backgrounds allows this research to expand the boundaries of sources and types of data. This will minimize the bias on historical constructions, which often occur due to different authors' points of view, usually

coming from a different group of countries, religions, races, classes, political views, and belief systems (Buckley, 2016).

This study uses a convergent model triangulation which is a mixed-method in which the quantitative and qualitative data processing is simultaneously conducted (Bandur, 2019, p. 31). The process of convergent triangulation is also a way to be able to juxtapose quantitative facts and qualitative interpretations as critical media and validate a historical event before historiography is formed because of the construction of the two sources.

Qualitative sources use the archive to find comprehensive traces that can be taken through written sources (Gottschalk, 1975; Herlina, 2020). One of the abundant sources of writing is the digital archives of newspapers. For historical research, the use of newspaper databases is a new way to get further analysis and richer exploratory results to look at phenomena in a single subject and time (Bingham, 2010). In addition, a database that has a large number of data sources provides an opportunity for researchers to see a complete chronological sequence, accompanied by points of view and assessment of certain phenomena in the past (Bowie, 2019). Therefore, this research considers using retrieving newspaper content from the family planning database which archives various Dutch news sources, including the Dutch East Indies.

In addition, the study will analyze with the quantitative descriptive from Scopus database was used to obtain information about the trends of Dutch East Indies scientific publications. The search for articles in the Scopus database was carried out on July 13, 2021, using the keyword Affilcountry (Indonesia), and we took articles only from 1849 until 1940. From these search results, we obtained 201 articles. The facts of processing the Scopus Database will also be compared with several similar studies, such as the Hesselink (2019) studies which uses the *Geneeskundig Tijdschrift voor Nederlandsch-Indië* (GTNI) journal database. Meanwhile, the addition of numerical facts that were taken to explain the condition of Indonesia at that time used a national survey and census by the Bureau of Statistics. This data is very important to describe the historical context based on social, economic, and other conditions which of course will be different from the current context.

Dutch East Indies Policy System

In general, the monarchical countries in Europe do not give a niche to the democratization of society in providing two-way interaction with social and political problems for a country. As stated by Nugroho (2014, p. 81) that public policy in these countries, including the Kingdom of the Netherlands, sees public policy as a legal product that has centralized power on one side without any interaction between society and the state. Thus, a common problem that is considered important to be resolved by public policy is not seen from the perspective of the community holistically that is from all groups and layers of society, but from a small group of authority.

However, it does not mean that the policy system of a monarchy is not better than a form of democracy that upholds the values of freedom of speech in public policy

making. What Nugroho concludes is that on the one hand, countries such as the Dutch East Indies could have an efficient policy system because a law which is the product of a more concise policy with the loss of public participation, but it required to be considered is the availability of a professional political elite. This needs to be a critical part of the policy system in the Dutch East Indies that the reality is that the policies issued are very strict for the benefit of the government and colonial activities without looking at the welfare of society for all groups which should be the main goal.

Furthermore, the political system adopted by the Kingdom of the Netherlands is the *trias politica* system which was first introduced by the French philosopher and political theorist, Charles Montesquieu (1689-1755) in his publication entitled *l'Esprit des Lois* in 1748. Exactly one century Then, in 1848, during the spring revolution in Europe, King William II decided to change the political system in the Netherlands in the era of parliamentary democracy by appointing Johan Rudolph Thorbecke to revise the constitution. In the same year, Thorbecke wrote a new constitution based on Charles Montesquieu's *trias politica* in which the political system has three functions, namely (1) The legislative function is the Government (the Queen and the Ministers) (2) The executive function is the provincial, city, and regional government. colonies (3) The judicial function is in the state justice system.

One of the hallmarks of the these states system is the existence of a policy layer based on macro, meso, and micro levels values (Hill & Hupe, 2002; Miller & Demir, 2007; Nugroho, 2014). Macro, such as laws are made to make legal products in general that are published and are in a strategic position. The main basis for carrying out the activities of the Kingdom of the Netherlands is *de grondwet* (constitution or basic law) which was first made in 1814 and continues to be updated until now. In the 1922 constitution, the concept of colonialism was abolished and replaced colonial countries such as the Dutch East Indies, Suriname, and Curacao as part of the kingdom. Thus, the political position of the region is in the legal status of the Dutch kingdom which functions as the executor of the constitution through technical regulations at both the meso and micro levels. The policy is bureaucratically implemented by the Governor General in a hierarchical manner down to the resident, regent, to *lurah*.

Considering the role of the Dutch East Indies Government as the executive, implementing meso, micro levels policies would weaken the function of the "Volksraad" (people's council), which was created for the first time in 1918 and is the only institution that should be at the legislative level and have representation in certain groups, including Indonesian and other minority groups. This People's Council was only used as an adviser to the Governor- General of the Dutch East Indies without having the right to question the control of the government budget. Therefore, in the end, there are few problems and demands from non-European groups to get attention due to restrictions to participate in the policymaking.

Educational Policy

After ethical politics to develop a more inclusive education, the colonial government took a long time to create policies to realize the goal. De Angelino, 1931 (p. 1994)

assesses education as a social force in the Dutch East Indies, facing complex problems, especially the very different social structure, especially from the Indonesian group, the Chinese and Arab middle classes, and European groups, to fulfil the values of justice, need to adapt to the social environment in which these groups stand. In fact, the European education system is difficult to impose directly on the Indonesian community, especially in the outermost regions, which do not speak Dutch. On the other hand, differentiating education classes could mean that the policies of the Dutch East Indies Government were discriminatory and did not respect the value of education for all groups. This became a dilemma for the Dutch East Indies government to face a double-edged sword situation.

As in Table 1, it took almost a decade for the government to provide education other than the *Eurospeesch Lagere School* (ELS) for the European community, namely *Hollandsch Inlandsche School* (HIS) which was created for the Indonesian group. Although in practice, HIS was created for the nobles and elite Indonesian and still closed learning opportunities for the marginalized Indonesians. For those who did not have the opportunity to receive an education at HIS, the People's School (*Volkschool*), commonly known as *Sekolah Rakyat* in Indonesian, was the only option for the low-middle Indonesian group to receive elementary education in the colonial government's official education program.

Table 1. Stratafication education system of Dutch East Indies Administration

Education Level	School	Duration (years)	Est. Years	Prerequisite	Target Students
Elementary School	*Eurospeesch Lagere School* (ELS)	7	1817	-	European
	Hollandsch Inlandsche School (HIS)	7	1914	-	Nobles and elite Indonesian
	Holandsch Chineesche School (HCS)	7	1908	-	Chinese
	Volkschool (People`s School)	3	1906	-	All Indonesian
	Schakel School/ Vervolgschool	5	1915	Volkschool	Gate education from *Volkschool to MULO*
Junior High School	*Meer Uitgebreid Lager Onderwijs* (MULO)	3 for ELS, 4 for others	1914	HIS, HCS, Schakel School	Non-European
Senior High School	*Algemeene Middelbare School* (AMS)	3	1919	MULO	Non-European
	Hogereburgerschool (HBS)	5	1860	ELS	European

Educational opportunities were still considered arbitrary for the entire community under the Dutch East Indies Government. This can be seen from the education time and the number of educations which that can be 2-3 years adrift between the Indonesians and the Europeans. For the European community, they can get an ELS (7 years) and HBS (5 years) with a total of 12 years to graduate senior high school level. As for the Indonesian upper class, they usually finish through HIS (7 years), MULO (4 years), and AMS (3 years) with a total of 14 years. For the lucky marginalized Indonesian people, they can get education through *Volkschool* (3 Years), *Schakel School* (5 Years), MULO (4 Years), and AMS (3 Years) for a total of 15 years.

In those days, completing secondary education was a high achievement, thus it was not a difficult effort for secondary education graduates to find a job, even in a government position. In addition, for those who are interested in continuing their education in higher and vocational education, there are several educational options such as medical school (STOVIA), Law School (RHS), Assistive Teacher School (HIK), Institute of Technology (THS), Agricultural School (*Landbouw School*), Trade School (PHS), and many other colleges and vocational schools.

On the other hand, the provision of education for the marginalized Indonesian community is provided by the intellectuals of the Indonesian movement that is independence from government's education scheme. Several movements created their own educational organizations, such as the People's College or *Volksuniversiteit* (1928), Taman Siswa (1922), Ksatrian Institute (1923), and the *Indonesisch Nederlandsch School* (1926). This shows that at the beginning of the 20th century, there were more and more national movements that prioritized education as a means of fight for the welfare of the indigenous groups who had long been trapped in the circle of life without modern education.

In the 1922 constitution Article 195 emphasize that education is the main duty of the Kingdom to provide free public education that respects every background of faith. The government is obliged to provide a sufficient number of public elementary schools for each region, all of which are borne by the government. However, the ethical political momentum as the basis for expanding educational opportunities for all groups was not in line with the economic policies of the Dutch East Indies administration. As in Table 2 shows that the total government spending on education shrank sharply from 1932-1940. One of the components that was most reduced was the expenditure on education funds for the People's School which in 1932 was 20 million Gulden, and the remaining 3.6 million Gulden in 1940. While other education categories, including western elementary schools (ELS and HIS), secondary schools, vocational, and higher education experienced a slight decline but not extreme.

However, the expansion of government policies to provide wider education for all people groups and the efforts of the intellectual movement of the Indonesians to organize their own education have not been able to release them from the ignorance trap. It can be seen that the literacy level of the Dutch East Indies community, especially the Indonesian, is at an alarming number. From the 1930 statistics as shown in Table 3, it shows that the Indonesian has the lowest proportion of literacy compared

to other ethnic groups. Where only 10.8% of men and 2.2% of women can read. the gap was very wide when compared to European community where both men and women have literacy rates above 70%.

Table 2. Government Expenditures on Education, 1932-1940

Year	Education Expenditures based on facilities						Other Expenditures	Total
	General Education				Vocational Education	Higher Education		
	Volksschool	European Elementary Schools	Secondary Education	Total				
1932	20369,6	15490,1	8049,6	43909,3	7889,4	7889,4	2381,6	55623,9
1933	19027,9	14191,9	7158,1	40377,9	6689,0	6689,0	2161,4	50197,2
1934	14440,5	11979,7	5845,7	32262,9	4666,1	4666,1	1727,6	39467,2
1935	11493,4	9668,7	4656,7	25817,7	4008,6	4008,6	1822,7	32373,2
1936	10714,7	9360,0	4719,2	24793,9	3488,8	3488,8	1716,0	30717,1
1937	4113,0	9624,7	4888,9	18626,6	3059,3	3059,3	2034,9	24467,9
1938	4230,9	11410,4	6352,4	21983,9	3765,5	3795,5	2882,7	29527,4
1939	3791,9	11920,1	7156,9	22838,9	4360,3	4360,3	3950,2	23125,3
1940	3655,9	12348,2	7690,8	23649,9	5097,8	5097,8	3880,2	33728,0

Source: Central Berau of Statistics, 1940.

Table 3. Literacy Level based on Ethnic Group of Dutch East Indies in 1930

Gender	European	Indonesian	Chinese	Other Asians	Total
Men	78,6 %	10,8 %	39,5 %	37,5 %	11,9 %
Women	71,2 %	2,2 %	12,4 %	3,9 %	2,6 %
Total	75,2 %	6,4 %	28,9 %	22,4 %	7,2%

Source: Central Bureau of Statistics, 1947, p. 26.

The population of the Dutch East Indies in 1930 (Central Berau of Statistics, 1940), for instance, Indonesians had 59.138 million people or 97% of the total population of the Dutch East Indies. While other nations such as Europe only amounted to 240 thousand people or 0.4% of the total population. And other Nations no more than 3% of the total population. This caused the number of illiteracy rates in the Dutch East Indies to be very large. In total in the same year, 92.8% of the population of the Dutch East Indies could not read and write. Whereas in that year, the age of ethical politics has almost entered its third decade.

Furthermore, of those who can read and write that is 7.2% 0f total population, there is a only 9.3% of them can write and read in Dutch. In detail by nationality are Europe (95.3%), Indonesia (5%), China (11.7%), and Other Asia (3.8%). This figure also shows that a proportion of Indonesians group cannot have the ability to write Dutch. Though, in the lower education system, except for the People's School, the official language of instruction is Dutch. Dutch is also very commonly used in newspapers that are often circulated in Dutch East Indies which is one of the effective media for

the development of general knowledge, especially the latest and essential information from Europe and overseas.

This shows that ethical politics vision to create prosperity for the Indonesian community cannot be achieved yet. Fakhriansyah & Patoni (2019) argue that the educational policies issued by the Dutch East Indies colonial government were in fact only directed at their political and economic interests. Moreover, according to Marwati and Doenod (2008, in Fakhriansyah & Patoni, 2019) the existence of the Indonesian group in universities is very minimal where in the 1920-1929 period, at most only 44 Indonesian were in college. Even until the end of colonialism and the beginning of independence, Indonesia only had about 400 scholars to drive the wheels of government (Gross, 2011). However, another opinion from Hesselink (2019, p. 142) considers that in particular, the large number of investments in STOVIA by the Dutch East Indies Government has a positive impact on the increasing number of Indonesian doctors who directly increase the number of medical scientific publications.

In short, it can be illustrated that the role of S&T is still contributed by European communities who can easily get exclusive opportunities to get better educational opportunities and easier networking positions with S&T centers in Europe. On the other hand, the Indonesian people are not in an ideal position to play a role in the development of S&T in the Dutch East Indies because even though they already have the opportunity to get a better education, there is still an educational stratification that distinguishes the natives and other classes of the nation.

The Role of Researcher

The beginning of modern research activities in the land of Indonesia was started by Jacob Bontius (1592-1631). He conducted research in the fields of tropical medicine, plants, and diseases in Batavia during the critical times of the *Vereenigde Oostindische Compagnie* (VOC) which was trying to occupy Batavia and in opposition to Sultan Agung, the prince of Mataram. Jacob Bontius actively published books in this field, and several semi-finished books were published after his death. This is considered to be the starting point for the development of modern S&T in Indonesia.

However, it would be difficult to determine that this meant that prior to these times no scientific activity was conducted. According to Dittrich (1997) who considered that the Dutch painter, Phillips Angel (1616-1683) had already painted the Javanese rhino for the first time and spread it to Europe around 1630. This can be seen from Philips' painting which is identical to the illustrations in the book entitled *Historia Naturalis et Medicae Indiae Orientalis* by Jacob Bontius in 1658. In addition, Jacob's assumption as the first researcher in the Dutch East Indies could minimize the role of the development of S&T through research by the earlier Nations in the Archipelago. As mentioned by Boomgaard (2008) that there is a misperception that is commonly considered that western nations are always the ones who transfer technology and knowledge to eastern nations. Whereas for a long time there has been a transfer of knowledge among Asian nations, even from east to west. Therefore, it is very natural that Gross (2014, p. 48) considers that until the end of colonialism, most of the Dutch

elite 'arrogantly' regarded the natives as those who had 'backward' knowledge and highly respected the high degree of European knowledge.

However, in practice, it would be justified to assume that modern research will be mostly carried out by European researchers. From the results of searching the Scopus database, there are 133 authors who produced 201 scientific articles in Indonesia in 1849-1940. Dr D. R. Koolhaas is the scientist who produces the most scientific articles related to research in Indonesia. He produced 11 scientific articles in 1930-1940. Koolhaas is a Dutch expert in chemistry, chemical engineering, biochemistry, genetics and molecular biology, pharmacology, toxicology and pharmaceutics. In 1930-1932 Koolhaas conducted research on essential oils at the Phytochemisch Laboratory within the Botanical Science Center and the R&D that was part of the *Algemeen Proefstation voor de Landbouw* [Balai Besar Agricultural Research] merged into the Analytisch Laboratory, and the joint group named itself the *Laboratory of voor Scheikundig Onderzoek* in 1934. Koolhaas served as Head of *Laboratory voor Scheikundig Onderzoek* in 1933 – 1939 (Ministry of Industry, 2021). Most of the research conducted by Koolhaas concerns the discovery of essential oils from plants such as *Eryngium foetidum*, *Hydnocarpus heterophylla*, *Litsea cubeba* (Lour.) Pers., and *Aleurites trisperma*.

Table 4. The 10 Highest Researchers that Produce Articles in Dutch East Indies, 1849-1950.

Authors	**Subject Areas**	**Number of articles**
Koolhaas, D. R.	Chemistry, Chemical Engineering, Biochemistry, Genetics and Molecular Biology, Pharmacology, Toxicology and Pharmaceutics	11
Gorter, K.	Pharmacology, Toxicology and Pharmaceutics, Chemistry, Biochemistry, Genetics and Molecular Biology	10
Krijgsman, B. J.	Neuroscience, Medicine, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology	8
Posthumus, K.	Chemistry	7
Bonne, C.	Chemistry	6
Meijer, Th. M.	Chemistry, Chemical Engineering, Biochemistry, Genetics and Molecular Biology, Pharmacology, Toxicology and Pharmaceutics	5
Koumans, A. K. J.	Medicine, Pharmacology, Toxicology and Pharmaceutics, Environmental Science, Immunology and Microbiology	5
Kreiken, E. A.	Physics and Astronomy, Earth and Planetary Sciences	5
Sitsen, A. E.	Medicine, Biochemistry, Genetics and Molecular Biology	4
van Veen, A. G.	Chemistry, Biochemistry, Genetics and Molecular Biology	4

Source: Scopus Database, July 2021.

In addition to the prolific researchers above, this paper assesses that the role of Prof. Melchior Treub became essential in the development of S&T in Indonesia, especially in promoting the Buitenzorg Scientific Center (BSC) or commonly known as Buitenzorg Botanic Gardens/Bogor Botanical Gardens, to the international arena. He is a Dutch botanist who graduated from the University of Leiden with a doctorate. Treub discovered several new types of Lycopods and cultivated them in hopes that all aspects of their embryology would be revealed. Treub was trusted to be the director of the BSC in 1880-1910 which immediately built an image as a tropical natural science R&D to scientists in Europe. Through his important position, he builds physical spaces for conducting tropical natural science research such as libraries, workspaces, grants, guest research residencies, and infrastructures such as microscopes, chemicals, and cataloguing. Before Treub, some assets owned by BSC were not managed. All herbarium collections prior to 1844 were brought to the Netherlands, including several examples of species in Java discovered and named by Carl Ledwig Blume in the early 19th century. Through his leadership, BSC developed into a professional scientific institution with knowledge of tropical nature with various types of species in it. According to Gross (2014, p. 119) that the success of the Botanical Gardens is the envy of the world's botanists with institutions that are the centre of the circle of botanical science. But unfortunately, this achievement was never achieved again until the era of the Dutch East Indies government ended, even today under the government of the Republic of Indonesia.

Although they were not dominant actors, several names of Indonesian scientists appeared in scientific articles published in 1849-1940, including Raden Soehadi Koesoemohadipoetro who was a medical researcher at the Niederlandisch-Indischen Arzteschule in Soerabaja (NIAS). The purpose of establishing NIAS is to educate doctors who can directly work to serve public health. NIAS then changed its name to Faculty of Medicine Universitas Airlangga in 1950 (UNAIR, 2018).

In addition, Sutomo Tjokronegoro was the first professor of pathology at the Faculty of Medicine, Universitas Indonesia in 1950. He is known as the Father of Pathology in Indonesia who researches cancer. Sutomo received his medical degree at the Batavia Medical School in 1935. He taught pathology, forensic medicine, and internal medicine. Sutomo published an article in the journal *Geneeskundig Tijdschrift voor Nederlandsch Indië* [Dutch Indies medical journal] which was the most important medical journal in Indonesia during the Dutch colonial period. Sutomo publishes articles on forensic medicine, cancer, ulcers, and tuberculosis. In 1942, he became the editor of the journal (Pols, 2017). Sutomo also wrote a book entitled "Are You Able to Build Our Unity Language?", "A Few Things About Doctor of Justice". In addition, M. Soewarno is an Indonesian scientist who produced a scientific article in 1930 regarding lead poisoning. He graduated STOVIA in 1920 then joined the NIAS. During his studies at STOVIA, he was active in the movement with indigenous medical school students and was one of the founders of the Boedi Oetomo association (Dahlan, 2017).

The fact that Indonesian researchers are commonly contributed to the medical field is in line with the GTNI publication, the role of the Indonesian writer in special journal articles for medical problems can be seen more. Hesselink (2019, p. 120) calculated that of the 4500 articles published in 80 scientific editions, there were 12% of the writings written by Indonesian doctors, totalling 195 authors. From the 195 Indonesian authors, there are authors who have published more than 10 articles including Raden Mas Sardjito (29 articles), Mochtar (25 articles), Raden Soesilo (23 articles), Mohamad Amir (22 articles), Mas Soetopo (11 articles). In addition, there are two writers of Chinese descent including Sie Boen Lian (15 articles) and Loe Ping Kian (14 articles).

Most Indonesian researchers are doctors who carry out medical research. This is inseparable from the policies of the Dutch East Indies administration and the war effort against various kinds of epidemics such as Cholera, Leprosy, Hernia, Spanish Flu and Tropical Yaws. Investments and developments in broader educational institutions for Indonesian groups such as STOVIA and NIAS allow more non-European doctors to be produced. In addition, the urgent need for research resources cannot be met considering that special research and development centers for the disease are still very minimal in Indonesia and the mastery of medical knowledge is still limited.

The Role of Research Organization

In general, R&D institutions in Dutch East Indies that have a long history can be mapped from various perspectives. The initiation of R&D institutions cannot be separated from the enlightenment apostles who have a mission to educate the colonial community. As stated by Gross (2011, p. 214) that since the mid-19th century the S&T community has been divided into two camps which are amateur researchers and the government researcher. According to this distinguished, this study divides research organizations into two parts, namely based on organizational ownership which can be seen as independent and technocratic R&D.

Independent R&D, which usually consisted of amateur researchers, had spread before the government officially established R&D institutions. The quantity of independent R&D entities is often small and short-lived. Most of these organizations are non-permanent science, technology, and arts communities initiated by a handful of people. The initiation of an independent R&D institution for the first time was established by the spirit of J.M. It was Mohr who set up an observatory to observe Venus in 1761. Although he did not receive official approval from the VOC, his enthusiasm led J.C.M. Radermacher to create the first research organization called the Batavian Society of Arts and Sciences (*Bataviaasch Genootschap voor Kunsten en Wetenschappen*) in 1778 which was established for eleven years. In the early 20th century one of the largest scientific communities was established and survived, such as the Association for Natural History of the Dutch East Indies (*Nederlandsch-indische natuurhistorische Vereeniging*) which regularly published the Tropical Nature Journal (*De Tropische Natuur*) until the end of the Dutch East Indies era.

In addition, the organization of the Indonesian movement is often driven by intellectual groups even though its main goal is not to produce knowledge and technology. For example, Boedi Oetomo believes that bringing western knowledge and practices to Indonesian society can help their goal of escaping from the grip of Dutch colonialism (Gross, 2011, p. 10). This organization later grew and inspired other intellectual movements to contribute to introducing science and technology to the Indonesian community as an agent of the Indigenous enlightenment apostles, especially in creating educational activities and discussion groups, such as the General Study Club (*Algemeene Studieclub*), the Indonesian Study Club (*Indonesische Studieclub*), the Indonesian Women's Student Association (*Indonesische Vrouwelijke Studenten Vereeniging*), and the Indonesian Association (*Indische Vereeniging*). The goals of these organizations have in common as a medium of an intellectual struggle for the educated Indonesian, which cumulatively became an important position as a tool for the struggle for Indonesian independence.

On the other hand, the R&D institution belonging to the Dutch East Indies Government began in 1820 when C.G.C Reinwardt created the Natural History Commission (*Natuurkundige Commissie*) at the behest of King Willem I to investigate the potential development of the agricultural sector in the colonies. At that time, the BSC named Lands Plantentuin te Buitenzorg was already three years old but had not yet carried out a research function. In the decades that followed, part of BSC's activity was collecting plant species and developing catalogues. In 1852, BSC initiated Cibodas Botanical Gardens as a laboratory and experimental center that has an influence on research in the development of economic plant research (Ariati & Widyatmoko, 2017, p. 11). In the not so distant period, several institutions related to agriculture in the Buitenzorg area were established such as a chemical research laboratory, a forestry test station, Bibliotheca Biogenesis (Library Center), and the Treub Laboratory (Kementan, 2021).

Meanwhile, R&D Organizations in the medical and pharmaceutical fields actively carry out R&D functions, in 1890 the State Vaccine Development Institute, Parc Vaccinogen Instituut Pasteur or better known as the Pasteur Institute, was established as one of the institutions belonging to the Government of the Netherlands Indies and in collaboration with public institutions belonging to Lois Pasteur focused on biological research, microorganisms, disease, and vaccine development. This institution and its Pasteur Institute subsidiaries in various countries have made hundreds of thousands of vaccines in the first world war needed to protect soldiers to protect against typhoid fever. In addition, in 1888, the Central Laboratory for Public Health Laboratory Services (*Geneeskundig* Laboratory) was established, changing its name to the Eijkman Institute which focuses on disease and medical research.

In addition, universities and educational institutions have a research function to produce and develop knowledge. Universities are one of the important actors in the research ecosystem which can produce research through educators and students (Pandey & Pattnaik, 2015, p. 174). In the period after 1900s, the education institutions play an essential role to produce knowledge in several areas, especially medical field.

Started with Java Medical School in January 1851 in *Weltevreden*, now known as Gatot Subroto Military Hospital. The Javanese doctors at that time only hoped to overcome smallpox. Then, in 1901, the medical training of Javanese doctors was separated from the *Weltevreden* military hospital in *Hospitaalweg*, now known as Jalan Dr. Abdul Rahman Saleh. Finally, in 1919, the *School tot Opleiding van Indische Artsen* (STOVIA) was moved to *Burgelijke Ziekeninrichting Centrale* (CBZ) or now the National Center for Public Hospital (NCPH) Cipto Mangunkusumo. This step occurs because medical education in Indonesia is advanced and requires a wider space. On July 5, 1920, all teaching activities were transferred to Salemba 6 which was the forerunner to the establishment of the Faculty of Medicine, Universitas Indonesia (FMUI). FMUI is the oldest medical faculty in Southeast Asia (UI, 2010). The central function of educational institutions, especially in the field of medicine, indirectly affects the function of research in the field of health services. Some researchers at hospitals in Indonesia, for example, have an active research function, even in this field there are many Indonesian researchers who have contributed to the development of Indonesian S&T and still actively to lead the advance of medical field after independence.

Meanwhile, the forerunner of the research organization that overshadowed many R&D organizations in the Dutch East Indies started with the formation of the Dutch East Indies Research Council (N*atuurwetenschappelijk Raad voor Nederlandsch Indie*) which was established in 1927. In a government announcement published by De Locomotief (1927) the reasons for the establishment of this Research Council were:

> "The government has repeatedly felt the lack of a central body in the natural sciences, which was broadly constituted in terms of fields of activity, so scientific in composition and official position that it could act as the highest representation of the natural scientific world in the Dutch East Indies vis--vis Holland and abroad."

The purpose of the Dutch East Indies Research Council was as a government advisory body in the field of natural sciences, a center for collaboration of natural science practitioners in the Dutch East Indies, associations between researchers in the Dutch East Indies and other countries, and an institution that determines the direction of progress in scientific investigations and endeavors that can only be achieved through the collaboration of natural science researchers and the government. This council consists of representatives of existing research organizations and covers as much of the natural sciences as possible as appointed by the governor general. All costs were borne by the Dutch East Indies Government in the amount of NLG 2,500 a year for office supplies, publishing and labor expenses.

From the number of these organizations that contribute to research productivity, one of popular and measurable activities is through published scientific articles. In the Scopus database (Figure 1), publications produced by authors with affiliations to the Dutch East Indies show a fluctuating upward trend. In 201 articles, it shows that since 1922, the trend of publications has tended to increase, although at some point there has been a decline in publications. The peak of publications produced was in 1930, and again rose and fell until 1940. This shows that writing publications have gained a popular place for scientists in the Dutch East Indies, especially since the early 20th.

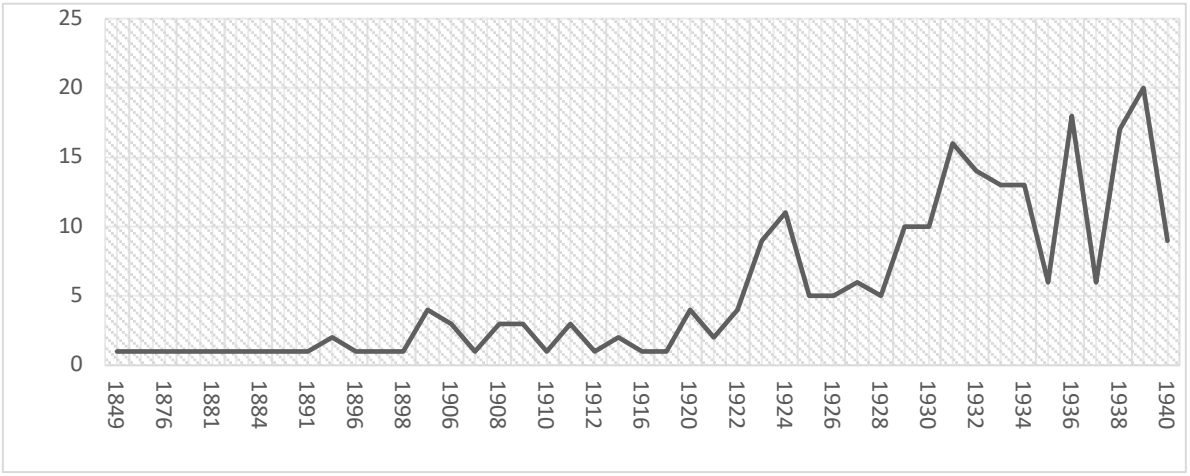

Figure 1. Scientific Articles indexed by Scopus from Dutch East Indies Affiliation during 1849-1940.
Source: Scopus Database, July 2021.

Likewise, trends based on its field are experiencing interesting dynamic changes. As shown in Figure 2, before 1900 almost no disciplines were dominant, only Industry and chemistry and medicine were slightly superior. In the period 1901-1920 publications with pharmaceutical concentrations experienced a significant increase despite Industry and Chemistry remained the dominant science concentration. Until the period 1921-1940, the field of science in scientific publications experienced heterogeneity in which Biology, Industry and Chemistry, and Medicine contributed more than 60% of all total Dutch Indies publications in the Scopus database. In addition, other fields such as Social Humanities, Psychology, Astronomy, and Engineering Sciences experienced a significant increase in the number of publications.

Both European and Indonesian writers have basically no striking differences from the resulting medical publications. Of the 195 Indonesian authors in the GTNI journal, it shows that almost all authors write topics on modern medical science, and only a few discuss traditional medicine. In a few examples, Mas Azhari wrote about the tools used by the circumcised dukun and S. Wiroreno wrote about the spleen case which came from traditional massage practices. (Hesselink, 2019, p. 123). Whereas, in the beginning of research activities in the Indonesian Archipelago, Jacob Bontius (1592-1631) initiating the research in traditional medicine, especially tropical medicine. This may be caused by the increasing number of diseases, and advances in S&T in diagnosis and treatment, as well as medical education can cause the diversion of the interest of Dutch Indies medical scientists from medical traditional studies.

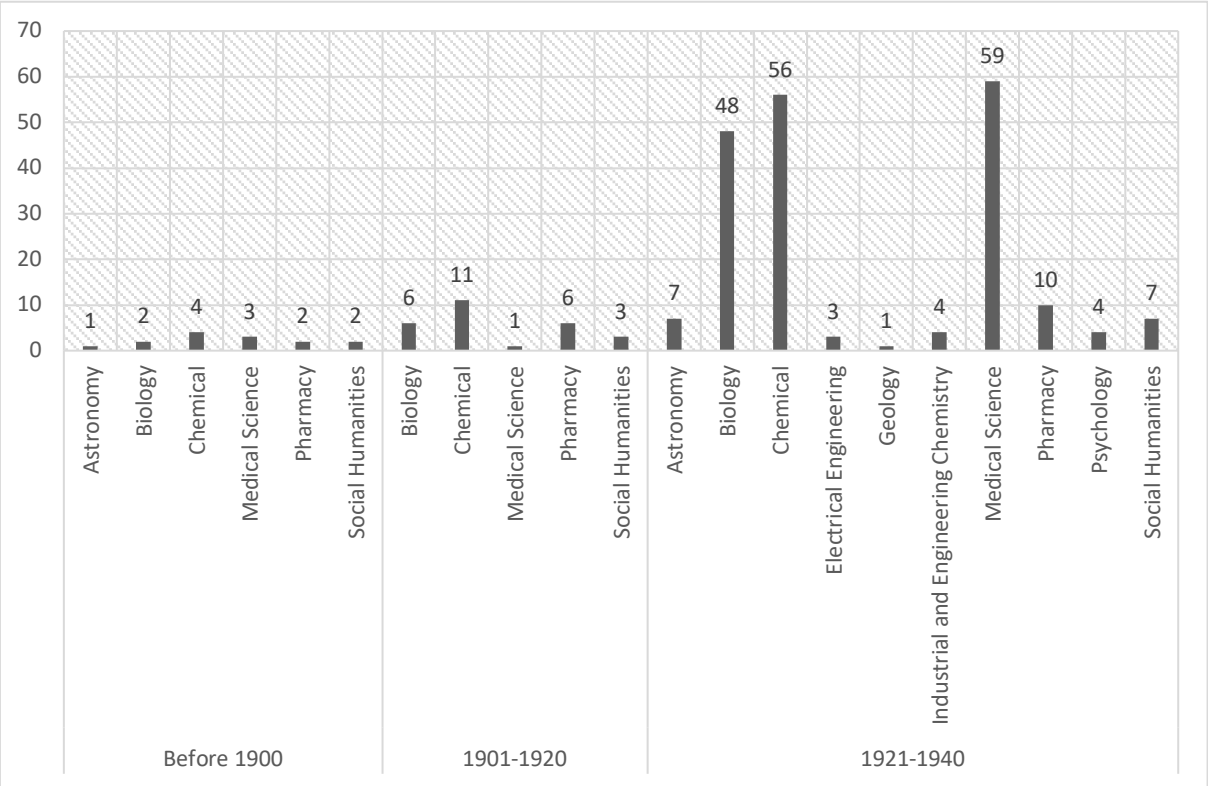

Figure 2. The Development of Scientific Publication by the subjects in 1849-1940

Meanwhile, the production of scientific publications based on R&D organizations has various portions. However, most of them are government-owned R&D institutions. As in Figure 3, the BSC is the institution that produces the most scientific articles with 51 articles. In addition to BSC, Pasteur institute and Eijkman Institute generally produce scientific articles with a total of 19 articles. Educational institutions such as STOVIA and NIAS, produced 26 articles. Other R&D such as Butenzorg Rubber Research Center, Tobacco Research Center Klaten, Pathological Laboratory East Coast of Sumatra, and Government Laboratory for Pest Research have cumulatively produced 17 articles. The number of research institutions involved in these articles consisted of 33 organizations.

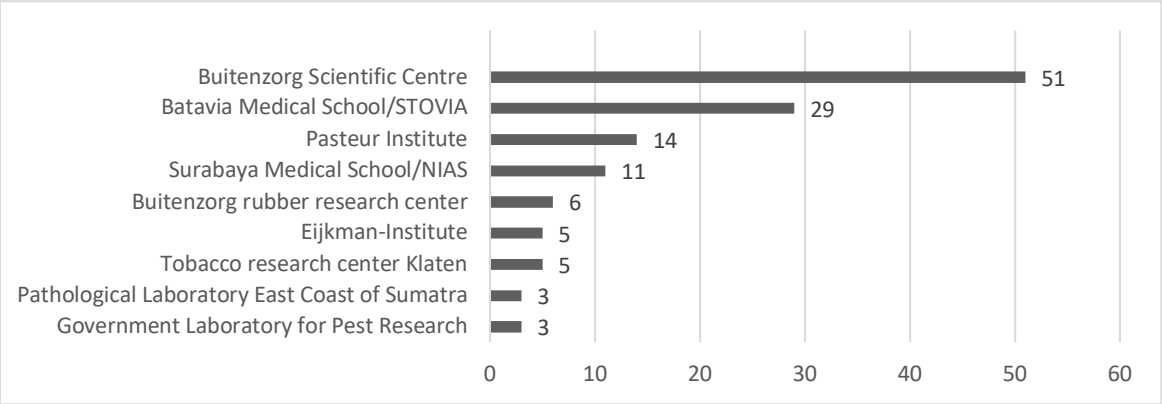

Figure 3. The Best Nine Institution that Produced Scientific Publication in 1849-1940
Source: Scopus Database, July 2021.

In details, from the results of the analysis of titles and abstracts on scientific articles in this period of SCOPUS database, 315 keywords were captured regarding S&T research in Dutch East Indies in 1849-1940 (Figure 4). The visualization shows that research object in that period was still concentrated on the islands of Java and Sumatra. Research conducted on the island of Java focuses on the fields of biology, medical science, pharmacy, and social humanities. This is indicated by the existence of BSC which has many laboratories for botanical, plantation, agricultural, chemical and zoological research. Scientists at that time were very interested in conducting research mostly on coffee, essential oils, tea leaf, tea pests, *lycophods*, *trypanosoma evansi*, bloodsucking Arthropods, *castilla elastica*, and chlorogenic acid.

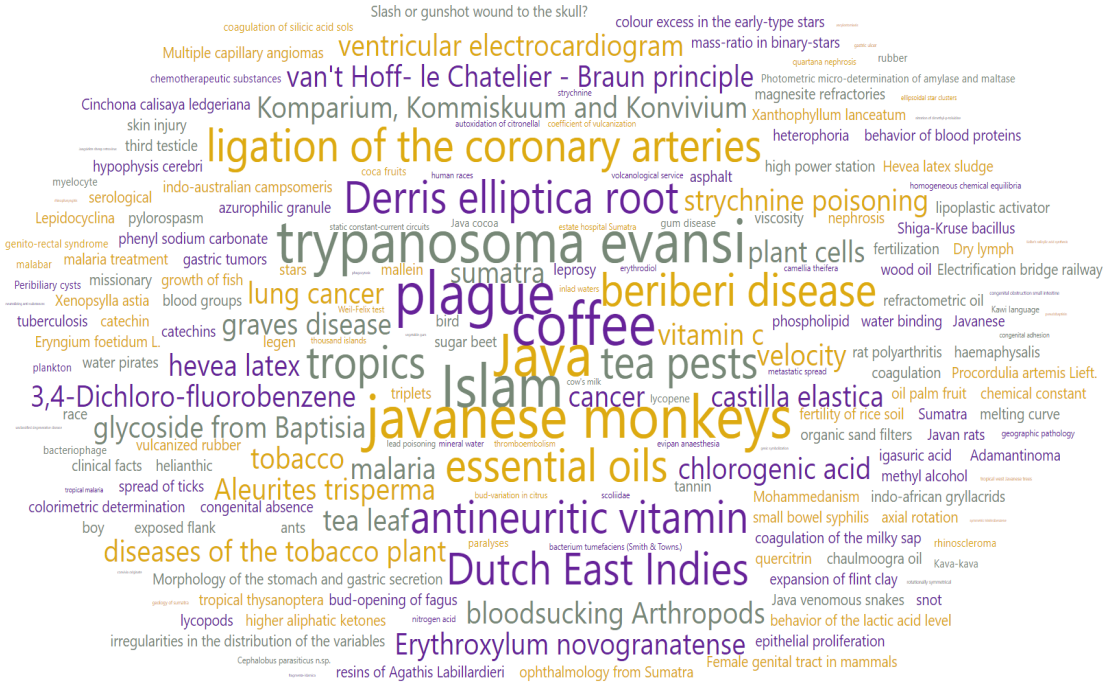

Figure 1. Keywords on Research Publication of Dutch East Indies Association 1849-1940
Source: SCOPUS Database, July 2021.

In addition, the island of Java has a wide range of medical school such as STOVIA in Batavia and NIAS Surabaya, which is a medical school that does a lot of research in the fields of biology, chemical, medical science, and pharmacy. Some of the research keywords carried out in these two places include gastric cancer, lung cancer, stomach cancer, pathology, beriberi disease, gastric tumor, malaria, antineurotic vitamin, ligation of the coronary arteries, Javanese monkeys, and graves' disease.

Conclusions

This research answers the long history of the development of Indonesian S&T under the Dutch East Indies government. The dynamics of education policy affect the creation of quality science and technology resources and develop diverse research trends. In general, this study answered in four focusses.

First, the development of Indonesian S&T cannot be separated from the influence of the Dutch East Indies education policy as one of the producing the supply of human resources on S&T. Although there are ethical-political policies that make education more inclusive for allpeople, the Dutch East Indies government still has a dilemma to provide equal education services for all ethnic groups. As a result, the supply of human resources on S&T is dominated by Europeans and some parts of the nobles and Indonesian elites. These people will be the determinants in the development of S&T in Indonesia until the era of the Dutch East Indies Administration.

Second, in accordance with an education system that is not truly inclusive, the most scientists are Europeans. They have a better advantage in getting better education and access to information on S&T sources in Europe. The most productive ranks of researchers at that time were Europeans, and only a few Indonesians. Indonesian scientists take a role in the development of S&T in the medical fields that is contributed by medical schools for Indonesian such as STOVIA and NIAS.

Third, the government-owned Research Organization is the biggest force in the development of S&T in Dutch East Indies. S&T was stirred based on the needs and desires of the Dutch East Indies Government alone. Authors from government research organizations are the authors who produce the most scientific articles. Meanwhile, the independent S&T community played a smaller role in the early 20th century. The striking thing in this period was the emergence of Indonesian intellectual organizations and groups in the mission of enlightening the lives of marginalized communities through European knowledge to be used as tools for the approach for the Independence of the Republic of Indonesia.

Fourth, Research trends are getting richer after the 1920s. In addition, the fields of science are increasingly diverse which previously focused on basic science, in that year there have been many applicable research, such as pharmacy and medicine. The development of S&T reached its peak in the 1920s-1940s when the S&T ecosystem in Indonesia began to form. Until the end of the Dutch East Indies government, at least it had bequeathed the institutions, research facilities, and Indonesian resources as the initial foundation of the S&T ecosystem for the Government of the Republic of Indonesia.

However, there are some limitations that need to be riched up on other studies. The advantage of development of S&T is not solely answered by the results of research publications, some are in the form of patents, product innovations, ang other outputs. This research still limits a product of S&T on research results in the form of scientific publications. In addition, scientific publications in that period were mostly local publications that were not indexed in nowadays publication databases such as Scopus. An overview in this study is a representation with Scopus as a sample whose population size is difficult to measure. So, it is necessary to conduct deeper quantitative research to focus on measuring the population size of publications.

References

Alian. (2012). Metodologi sejarah dan implementasi dalam penelitian. *Criksetra*, *2*(2), 1–17.

Ariati, S. R., & Widyatmoko, D. (2017). Bogor botanic gardens. *The Journal of Botanic Garden Horticulture*, *17*, 11–28.

Bandur, A. (2019). *Penelitian kualitatif. Studi multi-disiplin keilmuan dengan NVivo 12 plus.* Mitra Wacana Media.

Bingham, A. (2010). The digitization of newspaper archives: Opportunities and challenges for historians. *Twentieth Century British History*, *21*(2), 225–231. https://doi.org/10.1093/tcbh/hwq007

Boomgaard, P. (2008). Technologies of a trading empire: Dutch introduction of water and windmills in early-modern Asia, 1650s-1800. *History and Technology*, *24*(1), 41–59. https://doi.org/10.1080/07341510701616915

Bowie, D. (2019). Contextual analysis and newspaper archives in management history research. *Journal of Management History*, *25*(4), 516–532. https://doi.org/10.1108/JMH-01-2018-0007

Buckley, P. J. (2016). Historical research approaches to the analysis of internationalisation. *Management International Review*, *56*(6), 879–900. https://doi.org/10.1007/s11575-016-0300-0

Central Berau of Statistics. (1940). *Pocket edition of the statistical abstract of the Netherlands Indies 1940. https://www.catatannusantara.com/pustaka/n87tlwfzb8frkwc-ayjdp-ecbpt-t4dzj-jh3z4-kpde3-5bd92-dpr3p-6nnh4-5c4at-p79x4*

Central Bureau of Statistics. (1947). *Statistical pocket book of Indonesia 1941*.

Dahlan, J. (2017). *M. Soewarno*. https://kebudayaan.kemdikbud.go.id/mkn/m-soewarno/

De Angelino, A. D. (1931). *Colonial policy: The Dutch East Indies (Vol. II).* Springer Netherlands.

De locomotief. (1927, May 20). *Natuurwetenschappelijke Raad: Centraal orgaan van Indische wetenschappelijke instellingen. https://www.delpher.nl/nl/kranten/view?query=NATUURWETENSCHAPPELIJKE+RAAD:+Centraal+orgaan+van+Indische+wetenschappelijke+instellingen&coll=ddd&identifier=MMKB23:001701050:mpeg21:a00011&resultsidentifier=MMKB23:001701050:mpeg21:a00011&rowid=1*

Dittrich, L. (1997). The first painting of a Javan Rhinoceros in Europe. *Zoology*, *67*(2), 151–154.

Fakhriansyah, M., & Patoni, I. R. P. (2019). Akses pendidikan bagi pribumi pada periode etis (1901-1930). *Jurnal Pendidikan Sejarah*, *8*(2), 122–147. https://doi.org/10.21009/jps.082.03

Garraghan, G. J. (1957). *A guide to historical method*. Fordham University Press.

Gottschalk, L. (1975). *Mengerti sejarah: Pengantar metode sejarah*. UI Press.

Gross, A. (2011). *The floracrats: State-sponsored science and the failure of the enlightenment in Indonesia*. The University of Wisconsin Press. https://doi.org/10.1353/tech.2012.0003

Gross, A. (2014). *Belenggu ilmuwan dan pengetahuan: Dari Hindia Belanda sampai orde baru*. Komunitas Bambu.

Herlina, N. (2020). Metode sejarah. *Journal of Chemical Information and Modeling, 53*(9). Satya Historika.

Hesselink, L. (2019). *Para penulis Hindia*. Gelanggang Riset Kedokteran di Bumi Indonesia. Jurnal Kedokteran di Hindia Belanda *1852-1942,* 113–143.

Hill, M., & Hupe, P. (2002). Governance and managing implementation. In *implementating public policy,* 160–195. SAGE Publications Ltd.

Kementan. (2021). *Buitenzord scientific center.*

http://perpustakaan.pertanian.go.id/antiq/index.php?p=show_detail&id=595&keywords=

Laely, N. (2018). Sistem pemerintahan kolonial Hindia Belanda di onderafdeling Bonthain 1905-1942. *Jurnal Pendidikan*, *3*, 1–20.

Miller, H. T., & Demir, T. (2007). *Policy communities*. Handbook of public policy analysis: theory, politics, and methods, pp. 137–148. CRC Press. https://doi.org/978-1-57444-561-9

Nugroho, R. (2014). *Public policy* (5th ed.). Elex Media Komputindo.

Pandey, S. C., & Pattnaik, P. N. (2015). University research ecosystem: A conceptual understanding. *Review of Economic and Business*, *8*(1), 169–181.

Pols, H. (2017). *Founders of Indonesia's health and research institutes were prolific academic writers*.

Sukmana, W. J. (2021). *Metode penelitian sejarah*. Seri Publikasi Pembelajaran, 1(2), 2–5.

Suratminto, L. (2013). Educational policy in the colonial era. *Historia: Jurnal Pendidik dan Peneliti Sejarah*, *14*(1), 77. https://doi.org/10.17509/historia.v14i1.1923

UI. (2010). *Happy 90th birthday of FKUI's building. http://www.old.fk.ui.ac.id/?page=news.detail&id=15&lang=en*

UNAIR. (2018). *Sejarah pendidikan kedokteran di Surabaya*. https://profesi.dokter.fk.unair.ac.id/profil/sejarah

Wasino, & Hartatik, E. S. (2018). *Metode penelitian sejarah dari riset hingga penulisan.* Magnum Pustaka Utama.