JOSTIP

Vol. 8 No. 1 (June 2022)

The policy dynamics of Indonesia's science, technology, and innovation system (STI system): Current state of research and literature construction

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Article history: Received: 15 Feb. 2022| Received in revised form: 14 Sept. 2022| Accepted: 14 Sept. 2022| Published online: 21 Sept. 2022

Abstract

Policy dynamics is not merely a discussion encapsulating the policy cycle. Further, policy dynamics is widely applied to examine the evolution of policy, political dynamics, policy change, and policy development. In addition, policy dynamics have been implemented in a number of different topics and research areas. Discourses include changes in science, technology, and innovation (STI) policies in Indonesia in the last three years, gaining insight to be studied under policy dynamics. However an initial study with a bibliometric approach is required prior to conducting a review. This initial study aims to determine the current state of research and literature construction. This study employs bibliometric analysis by using VOSViewer. The results of this study include the mapping for several research on science, technology and innovation systems in Indonesia, in which the topics have been dominated by triple helix during 2010-2020, particularly in science Techno Park and innovation. In addition, approximately 55.7% of STI System in Indonesia topics are widely published in national publications such as national journals, and 44.3% are published internationally.

Keywords: *STI System; policy dynamics; literature construction; literacy; current state of research; Indonesia*

■ 1.0 INTRODUCTION

Understanding the policy dynamics has been unlimited, particularly with regard to the positivist conception of the public policy process as a policy cycle (Howlett & Ramesh, 2003). Alongside, policy dynamics is understood by measuring policy density (such as by observing the number of policies or policy instruments) and policy intensity (such as through the scope and ambition of policy) (Gravey & Jordan, 2021). Under the policy studies, policy dynamics is often accompanied with policy changes, contributing to agenda-setting studies (Brasil & Jones, 2020).

Policy dynamics has developed into a study, widely researched by scientists across the globe, such as: development of policy dynamics in the federal government system (Weaver, 2020); global-local education policies in New Zealand and Norway (Stray & Wood, 2020); and a number of other studies (see **Table 1**). In recent developments or at least in the last three years, policy dynamics are often equated with the evolution of policy (Carpenter et al., 2020; Laudari et al., 2020), political dynamics (Atinga et al., 2022; de Graauw, 2022), policy change (Howlett et al., 2022), and policy development (Hamann, 2020; Thaler et al., 2020). As such, it is thus interesting to navigate the study development of policy dynamics of the STI system in Indonesia. The STI system in Indonesia is considerably important to study in relation with recent developments, along with the enactment of Law Number 11 of 2019 concerning the National System of Science and Technology, and Presidential Regulation Number 78 of 2021 concerning the National Research and Innovation Agency (BRIN). The presence of these two regulations, hence, enables the dynamics and changes in the governance of research and innovation in Indonesia.

Table 1. Initial mapping of the literature review of policy dynamics

No.	Scope of study	policy dynamics as	Case Study	elements of policy dynamics
1.	Higher education policy dynamics (Jungblut et al., 2020)	policy dynamics	Europe	policy styles, main drivers, and extent of involvement of non-state actors
2.	Forest policy (Laudari et al., 2020)	evolution of policy	Nepal	policy and institutional shifts

No.	Scope of study	policy dynamics as	Case Study	elements of policy dynamics
3.	Urban policy (Carpenter et al., 2020)	evolution of policy	France, Italy, Spain and the UK	direction, object and impact
4.	Policy of COVID-19 vaccination (Atinga et al., 2022)	political dynamics	Ghana	framing of issue, social constructions generated from issue, stakeholder power dynamics and political contentions linked
5.	Healthcare policy reform (Howlett et al., 2022)	policy change	South Korea	macro elements of policies, namely policy paradigms and governance preferences
6.	Immigrant sanctuary policies (de Graauw, 2022)	political dynamics	San Francisco	role of leader/actors, influence sanctuary policies
7.	Welfare system policy (Hamann, 2020)	policy development	Cameroon	social policy development and implementation (historical contextualization)
8.	Planned relocation policy (Thaler et al., 2020)	policy development	Austria	developments in the problem, political, policy and population streams

Referring to the aforementioned conditions and description, the research questions include:

1) How is the current state of research from STI policy in Indonesia?
2) How are the literature construction of STI policy in Indonesia?

■ 2.0 METHODS

Through this research, the authors of this study aim to provide an overview in accordance with relevant literature regarding the research development on the dynamics of STI policy in Indonesia. This study implements literature review of articles, previously published in a number of literatures (to 2020). In particular, this study includes articles regarding STI in Indonesia with the distribution of the literature review as illustrated in **Fig.1**.

This research is classified as a bibliometric study, implementing a database from Google Scholar (Putera et al., 2021). The search on the database uses the keywords, such as "Science, Technology, and Innovation"; "STI"; “innovation system” and “Indonesia” in article title, abstract or keywords. In the first search, approximately 453 documents were obtained. Furthermore, restrictions were applied to journal articles and articles from conference proceedings written with Indonesian and English languages. At this stage, 95 documents were obtained, further analyzed by employing VOSViewer (Putera & Pasciana, 2021), indicating outcomes such as: publication trends analysis, distribution of source and highly cited articles, and keyword analysis.

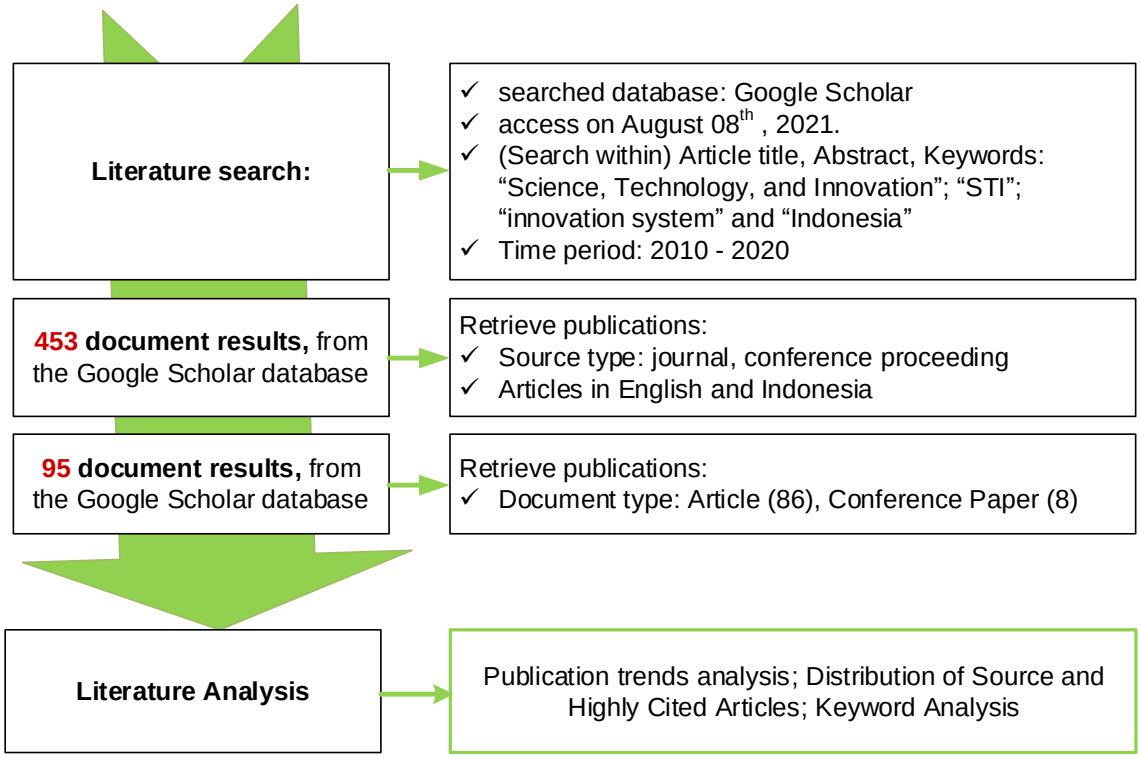

Figure 1. Literature Review Protocol

■ 3.0 RESULTS AND DISCUSSION

3.1 STI System Research Map in Indonesia 2010 – 2020

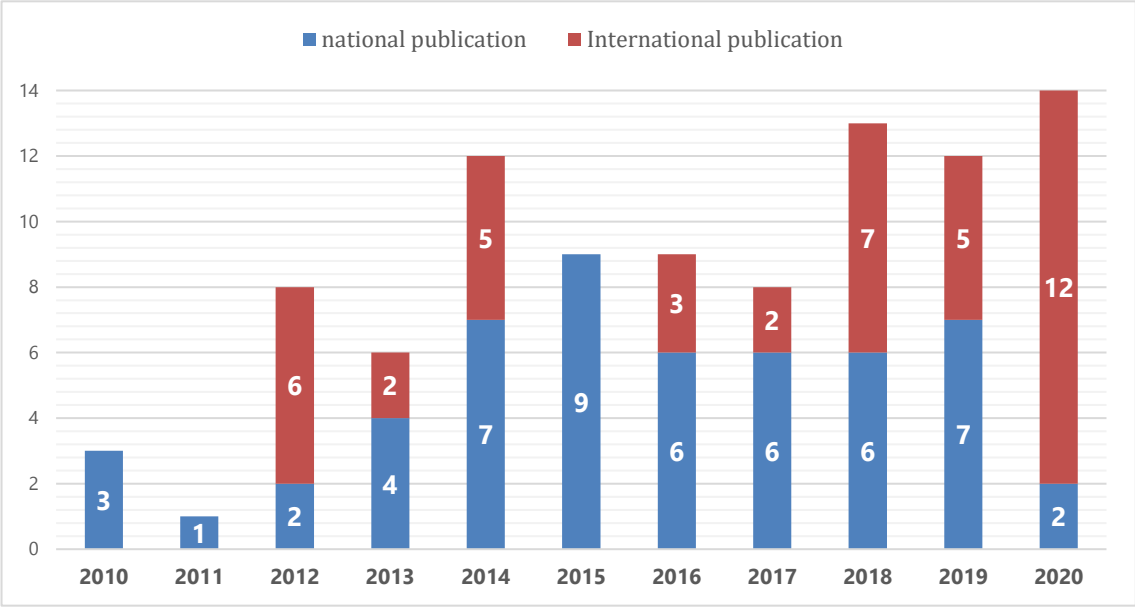

Figure 2. Trend of Publication Number on STI system in Indonesia within Period of 2010-2020

For the past 11 years, the trend of publications in the STI system in Indonesia has fluctuated. As reported by Google Scholar database, it is apparent that 2020 was the year of most publications (with 14 articles), followed by 2018 (13 articles), and 2013 & 2019 (both with 12 articles). Particularly, **Fig. 2** presents the distribution of international publications compared to national publications under the topic of STI Systems in Indonesia. Furthermore, **Fig.2** depicts that 55.7% of STI System in Indonesia topics are widely published in national publications such as national journals, and 44.3% are published internationally. Hence, these results indicate that publications in this area remain dominated by national publications and become the authors' chief preference for article publication.

Fig.3 demonstrates that 207 researchers have written and published their research results in the STI System area, forming the six research network clusters.

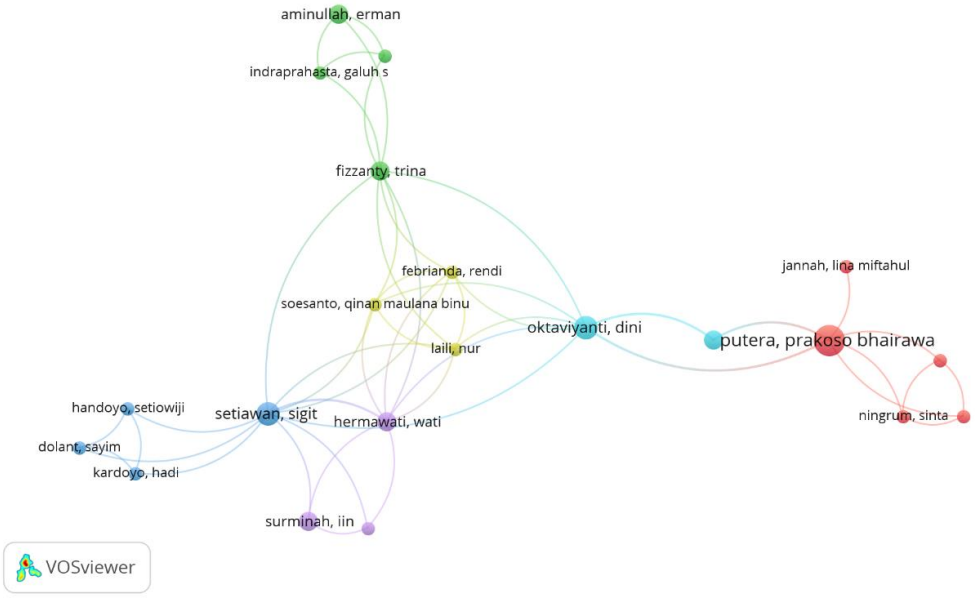

Figure 3. Research Network in STI System Research Area in Indonesia

Approximately 95 articles were published during 2010 – 2020 (**Table 1**), in which six articles received the most citations, including: "R&D, productivity, and exports: plant-level evidence from Indonesia" (Yang & Chen, 2012) with 79 citations, followed by "Scientific articles productivity and the collaboration intensity of Indonesian universities and public R&D institutions, entitled "Are there dependencies on collaborative R&D with foreign institutions?" (Lakitan et al., 2012) with 65 citations, and "Connecting all the dots: Identifying the "actor level" challenges in establishing an effective innovation system in Indonesia" (Lakitan, 2013) with 64 citations.

Since the fall of the national strategic industry at the end of 1990s and towards the beginning of 2000s, numerous studies reported the development of science, technology and innovation in Indonesia. However, a growing body of literature regarding the discussions on science, technology and innovation in Indonesia have been limited (Zuhal, 2008). Similarly, other research areas has been conducted, including: R&D performance on the budget (Arifin, 2011; Mulyanto, 2014); researcher performance (Lukman et al., 2018); R&D performance on exports (Yang & Chen, 2012); R&D spending efficiency (Afzal & Lawrey, 2014; Suwantika et al., 2020); scientific productivity and collaboration of universities with government R&D institutions (Setyono & Aeni, 2018); as well as cooperation and collaboration of R&D institutions (Lestari et al., 2019; Surminah, 2013; Widjajanti et al., 2020).

Rank	Title	Source title	Publisher	Cited by
1st	R&D, productivity, and exports: Plant-level evidence from Indonesia (Yang & Chen, 2012)	Economic Modelling	Elsevier	79
2nd	Scientific productivity and the collaboration intensity of Indonesian universities and public R & D institutions: Are there dependencies on collaborative R & D with foreign institutions? (Lakitan et al., 2012)	Technology in Society	Elsevier	65
3rd	Connecting all the dots: Identifying the "actor level" challenges in establishing effective innovation system in Indonesia (Lakitan, 2013)	Technology in Society	Elsevier	64
4th	An entrepreneurial, research-based university model focused on intellectual property management for economic development in emerging economies: The case of Bogor Agricultural University, Indonesia (Payumo et al., 2014)	World Patent Information	Elsevier	58
5th	The Important Role of Science and Technology Park towards Indonesia as a Highly Competitive and Innovative Nation (Kusharsanto & Pradita, 2016)	Procedia-Social and Behavioral Sciences	Elsevier	28
6th	Measuring the importance and efficiency of research and development expenditures in the transformation of knowledge-based economies: A case study of the ASEAN Region (Afzal & Lawrey, 2014)	International Journal of Asia-Pacific Studies	Universiti Sains Malaysia	17

Table 2: Top 3 STI System research articles with the most citations during 2010-2020

Similarly, other studies were conducted to reveal the interactions in the triple helix model (Fitriana, 2017; Lukmanul Hakim et al., 2018; Muljaningsih et al., 2018; Muzakir, 2019; Nurzal & Waluyo, 2012; Pennink, 2012; Perwitasari & Sutrisnanto, 2015; Putera, Oktaviyanti, et al., 2014), Quadruple Helix (Moradi & Dokhani, 2020; Pitaloka & Humaedi, 2020; Widjajani et al., 2016, 2018), Penta Helix (Deliana et al., 2017; Effendi et al., 2016; Hardianto et al., 2019; Muhyi & Chan, 2017; Rinaldi et al., 2020; Sihotang et al., 2019; Sudiana et al., 2020a, 2020b; Widowati et al., 2019), National Innovation System (Baark, 2016; Triyono & Prihadyanti, 2017), Regional Innovation System (Amriani & Prihatin, 2019; Ismiatun, 2015; Lestari et al., 2019; Mahirun, 2014; Maninggar et al., 2018; Narutomo, 2014; Oktaviana et al., 2014; Riskiawan et al., 2017; Ruswandi, 2013; Suresti et al., 2017; Syekh, 2019; Wijayanti et al., 2016; Witjaksono et al., 2020), sectoral innovation system (Heryanto et al., 2013; Heryanto & Supyandi, 2012; Kurnia et al., 2020; Soesanto et al., 2015), innovation system (Lakitan, 2013; Nafizah & Tiara, 2018; Putera et al., 2020), science techno park (Aldianto et al., 2018; Fadoli et al., 2019; Hatta, 2019; Hidayat et al., 2016; Kurniawan et al., 2018; Kusharsanto & Pradita, 2016; Muhammad et al., 2017; Mukhlish, 2018; Nurhayati & Purnomo, 2017; Pitaloka & Humaedi, 2020; Sudiana & Hendayani, 2020; Tolinggi, 2019), and technological innovation (Fayomi et al., 2019; Thalia & Thalib, 2019)

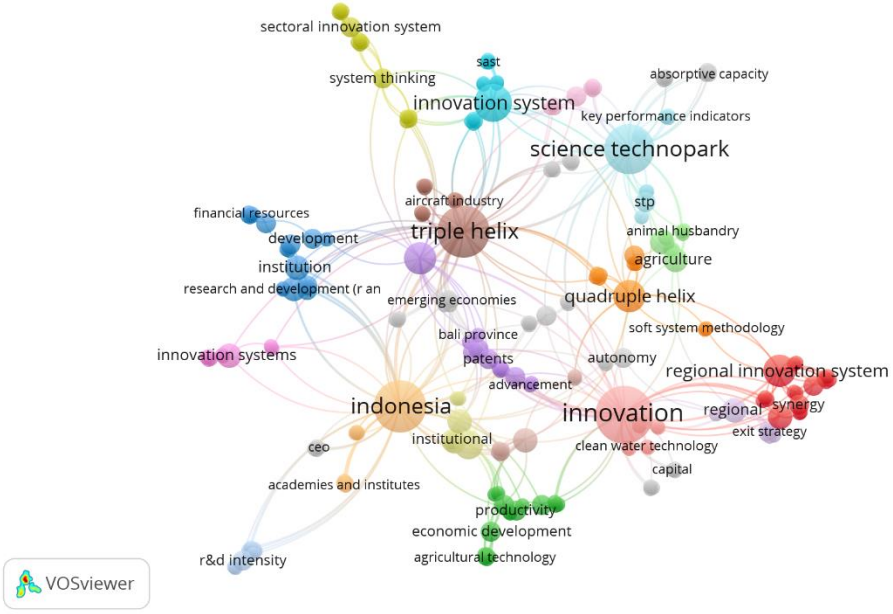

Figure 4. Network of co-occurring keywords

In addition, research in the area of science, technology and innovation has been initiated to study areas such as: science, technology and innovation policies (Aminullah, 2020; Lukman Hakim, 2015; Harymawan et al., 2020; Hoetman & Santa, 2014; Prihatina, 2010; Purwanggono et al., 2017; Putera & Jannah, 2012), regional innovation policy (Lorita, 2015; Maulana & Putryanda, 2017; Putera, Arifin, et al., 2014), R&D funding/budget (Akbar Adhiutama et al., 2018; Dobrzanski & Bobowski, 2020), R&D incentives (Firmansyah, 2010), R&D management (Hermawati et al., 2013; Sukur & Soesanto, 2014), government R&D institutions (Dimyati et al., 2020; Kardoyo et al., 2015; Nugroho, 2013), R&D institutions in the regions (Sampurna & Irwandi, 2017; Susanto & Priyambodo, 2014; Syekh, 2019; Wirasuta, 2019), valuation and performance of R&D institutions' intellectual property-patents (Aiman, 2014; Anggraeni, 2016; Herjanto, 2010; Imaniyati, 2015; Payumo et al., 2014).This data presentation is in line with the results of mapping, conducted through VOSviewer (Putera & Gustina, 2021) (see **Fig.6**) regarding science, technology and innovation systems over the last 10 years. However, the results of the mapping revealed that research regarding the dynamics of policies particularly the science, technology and innovation system in Indonesia, has been limited.

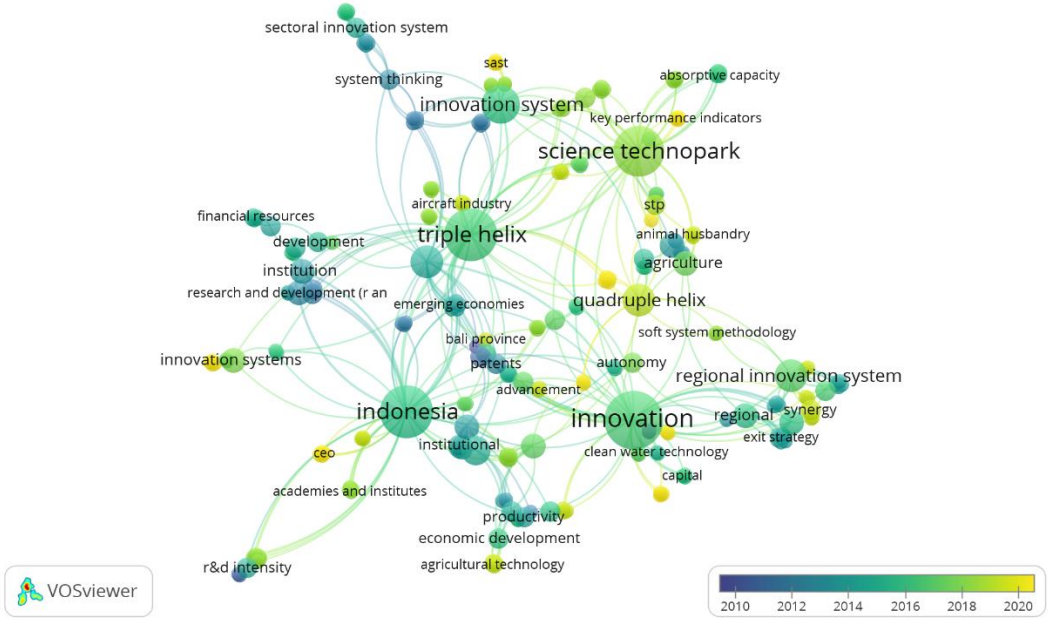

Figure 5. Item overlay visualization of co-occurring keywords

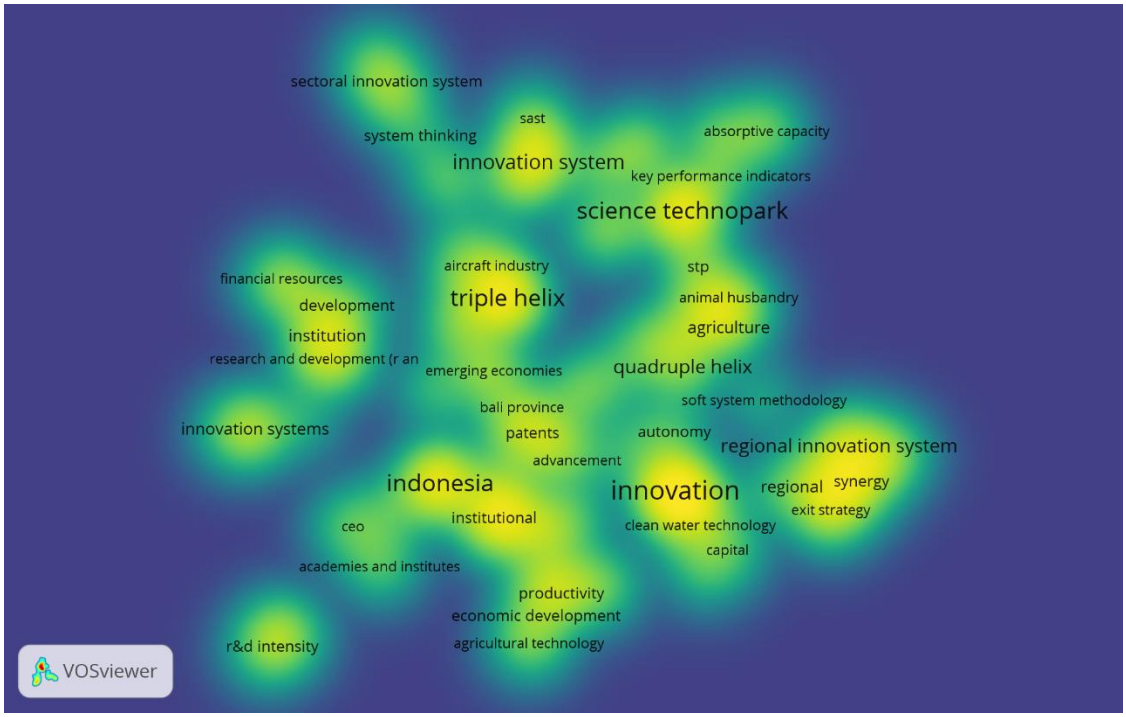

Figure 6. Mapping of Science, Technology and Innovation System Research in Indonesia for 2010 – 2020

Fig.4 presents that there were 304 research topics in the STI area in Indonesia, forming 29 clusters for 10 years. The most dominant nodes include topics related to the triple helix (cluster 8 is brown), science technopark (cluster 15 is light blue), innovation (cluster 10 is pink), Indonesia (cluster 16 is vanilla), innovation system (cluster 6 is colored pink), quadruple helix (cluster 7 is blue), and regional innovation system (cluster 1 is red).

Meanwhile regarding the emergence of research topics in **Fig.5** (overlay visualization), it is obvious that topics such as industrial R&D centers, government support, and scientific productivity have been dominant since 2010. Further, the topics including "local innovation system, R&D management, and patents" were dominant in 2012. Moving forward, the topic of STI related to "art and culture" was dominant in 2014, followed by the topic of "collaboration, STI in agriculture, innovation system, and triple helix" in 2016. Particularly in 2018, discourses related to commercializing, business incubators, creative economy, and entrepreneurship were common and become a concern. Meanwhile in 2020, a number of topics such as key performance indicators, habituation of S&T, and local uniqueness" were central.

Fig. 6 (density visualization) depicts a number of research topics has been widely discussed, as marked in bright

yellow background, including: "innovation, national innovation system, regional innovation system, triple helix, science technopark, and innovation system". However, other topics are less discussed, such as: "academies and institutes", the use of soft system methodology, system thinking, and agro-science technoparks.

3.2 The Importance of Research and literature construction on STI Policy Dynamics

Based on the mapping, the Research on Policy Dynamics of Science and Technology Systems and Innovation in Indonesia is potential to be constructed and conceptualized as illustrated in **Fig.7**. Topics including science, technology and innovation gain an interest to be discussed due to their importance as instruments in measuring competitiveness, inclusiveness and sustainable economic growth for a country, such as: in America countries (Padilla-Pérez & Gaudin, 2014); European continent (Karo, 2011); African continent (Saidi & Douglas, 2018); and in developing countries (Chaurasia & Bhikajee, 2016). As such, developing countries require the policy support in the development of appropriate science, technology and innovation, in order to master and engage with science, technology and innovation as well as to encourage growth for their countries (Niosi, 2010).

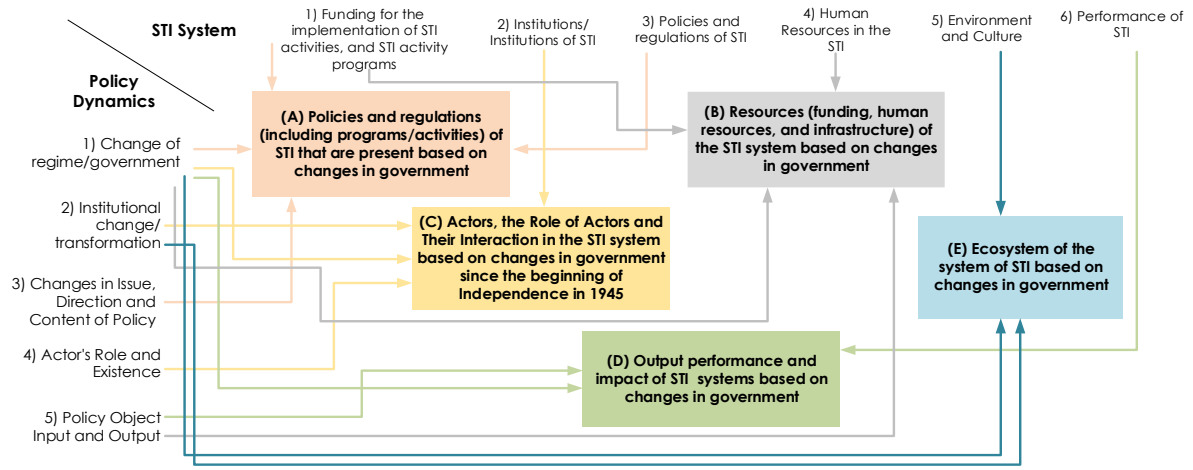

Figure 7. Construction Literature and Conceptual Extraction of Research on Policy Dynamics of Science and Technology Systems and Innovation in Indonesia

At the global level, a country's position is determined by a number of world-recognized indexes such as Global Competitiveness Index and Global Innovation Index (Ministry of Research, Technology and Higher Education, 2017). The two indexes provide a reference to measure the achievements of state actions and policies in an effort to surge competitiveness. Data from The Global Competitiveness Report (2019) reported the competitiveness rankings of countries worldwide, including Indonesia.

In this data, Indonesia is ranked 50 out of 141 countries (Schwab, 2019), indicating no-better outcome than the previous year (2018) which was 45 out of 140 countries. One notable notion lies in the discussion of competitiveness including the innovation system indicator, denoting that Indonesia's score was significantly low, achieving 38 with a rating of 74. This score, thus, indicates that the capacity to develop, adopt new products and process technology to meet market needs (for the future goals) remains low/ weak.

In other data, based on Global Innovation Index (2019), Indonesia's rank remains similar as in 2018, which was 85 out of 129 countries (Cornell University, INSEAD, 2019). Of the seven indicators of Global Innovation Index, Indonesia achieves a better rank in terms of Market Sophistication Indicator (48.8) or 64 out of 129 countries. Referring to the four selected indicators from the Global Innovation Index, such as: institutions, human capital and research, business sophistication, and knowledge and technology outputs, these four indicators provides a reference in perceiving the development and contribution of science, technology and innovation for a country. Hence, it is emphasized that Indonesia's achievements in science, technology and innovation remain “not-good”.

The value of the trade balance of technology products refers to a measurement regarding the ability of a country to produce science and technology products (Lall, 2010). There are three levels of technology intensity, including: low (low-technology), medium (medium-technology), and high (high-technology). In the context of science and technology production, a positive trade balance indicates that a country sells more science and technology products than those from other countries. In the period of 2012-2016 (Kementerian Ristekdikti, 2017), Indonesia is recorded to have exported numerous products with low technology intensity, such as: textiles, garments, and footwear products; meanwhile Indonesia highly imports for products with medium technology intensity (automotive products, processed technology, and engineering), as well as products with high technology intensity, such as electronics and electricity.

Such demonstrated condition is in line with data from World Integrated Trade Solution (2018), indicating that

Indonesia's exports in 2018 were dominated by raw materials such as fossil fuels, metals and minerals, and products from agriculture and forests. Further, data presentation exhibits that Indonesia's trade balance has been dominated by raw materials and low-tech products, thereby indicating that the contribution of science, technology and innovation remains significantly low in Indonesia. On the other hand, the results of science, technology and innovation are interpreted from the country's ability to produce and export products with medium and high technology (Roca & Eoin, 2020; Wu et al., 2020).

However, the Government of the Republic of Indonesia has made efforts to establish a system of science, technology and innovation, particularly when referring to a number of literatures and efforts to establish a system of science, technology and innovation initiated since the era of President Sukarno. It was not until 2002 that Indonesia had a law-level regulation enacting the regulation on science, technology and innovation through Law Number 22 concerning the National System for Research, Development, and Application of Science and Technology (Sisnas P3Iptek). Further, Sisnas P3Iptek in Indonesia served as a reference in the development of science, technology and innovation for almost 17 years, before finally subtituted by Law Number 11 of 2019 concerning the National System of Science and Technology.

■ 4.0 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Referring on the mapping results of a number of research on science, technology and innovation systems in Indonesia, the topics have been dominated with the triple helix, science Techno Park and innovation during 2010-2020. However, no studies has discussed the dynamics of the policy, regarding innovation policy, thereby encouraging the importance of conducting research related to this topic.

Consequently, future research is encouraged to examine the dynamics of the STI policy involving a time period from 1945 to 2020 in accordance with the evolutionary turn concept which studies a certain time span. The selection of the time period is in line with the idea that 1945 marks a year of Indonesia's independence as well as the starting step as an independent country. In addition, the time period of 1945-2020 addresses the concept that the study of policy dynamics is regarded as 'longitudinal studies' (Dudley & Richardson, 2005).

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