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Chapter 19

Agricultural Biosystems Engineering Education in Indonesia – A Journey

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Agricultural Biosystems Engineering Education in Indonesia – A Journey

Hadi K Purwadaria

History of Agricultural Biosystems Engineering (ABE) in Indonesia

The Development of Agricultural Mechanisation to Agricultural Engineering (AE) and Agricultural Biosystems Engineering (ABE) Study Programmes

Indonesia is the largest archipelago in the world, spreading latitudinally from 6° North to 11° South and longitudinally from 95° West to 141° East, or can be summarised as 5° S and 120° E (Wikipedia, 2022a). The total area is 1,919,440 km^2; however, since the land is only 24% and the water is 76%, it has a long coastline of 54,720 km. That constitutes an Exclusive Economic Zone (EEZ) of 6,159,032 km^2. Compared to Indonesia, the USA, for example, has a latitude and longitude of 37° N and 95° W, an area of about two times Indonesia at 9,826,675 km^2, but a coastline of about 1/3 of Indonesia's 19,920 km. Indonesia is flanked by two large continents, Asia and Australia, and by two large oceans, the Indian and Pacific Oceans.

The Indonesian population was 276.2m in 2022, ranking Indonesia as the 4th major populated country in the world, next to the USA, which has a population of 338.9m (World Population Review, 2022). Since the number of islands in Indonesia is very large – either 13,466 as surveyed by the National Coordinating Agency for Survey and Mapping (Bakosurtanal), Indonesia, 18,703 by the National Institute of Aeronautics and Space (LAPAN), or 17,508 by the CIA World Factbook – Indonesia faces a big challenge in delivering a qualified education equally to all people occupying many of the islands. Fortunately, most people are flocking to the five bigger islands of the country. Starting with the largest, the major islands in consecutive order are Papua (New Guinea), Kalimantan (Borneo), Sulawesi (Celebes), Sumatra, and Java. Though, the most populated islands are in reverse with their sizes: Java has 56.1%, Sumatra 21.7%, Sulawesi 7.4%, Kalimantan 6.2%, and Papua 3.2% of the total Indonesian population.

With Indonesia's geographical and population background, the development of ABE education across the country can be better appreciated. As may be common in other nations, ABE education started with Agricultural Mechanization then later transformed into AE, and presently some are transforming into ABE. The first study programme in Agricultural Mechanization was founded in the Faculty of Agriculture at Andalas University, city of Padang, province of West Sumatra, in 1957. Andalas University was the fourth university established by the government, following the Gadjah Mada University at Yogyakarta, DIY, the University of Indonesia at Jakarta, DKI Jakarta, and the Airlangga University at Surabaya, East Java.

The Agricultural Mechanization study programme in the Faculty of Agriculture spread from Andalas University to Gadjah Mada University in 1963 and IPB University (IPB) at Bogor, West Java in 1964. IPB was the former campus of the University of Indonesia, focusing on agricultural education and was located 60 km south of Jakarta, separate from the main campus in Jakarta. It received the Presidential Decree to stand out as an independent university in 1963. It should be noted that the first campuses of IPB were built in cooperation with the US government under the Kentucky Contract Team in 1955. It is important to mark that the Agricultural Mechanization study programme at IPB was established in the new Faculty of Agricultural Technology and Mechanization, which later transformed into the Faculty of Agricultural Technology (Mandang et al., 2018), not in the Faculty of Agriculture as in the two previous universities. This initiative would be followed later on by other similar universities in Indonesia. This first step taken by Agricultural Mechanization at IPB University will be followed up with a series of other initiatives characterising the study programme as the trendsetter of AE/ABE development in Indonesia until now.

Many of the faculty staff in the Agricultural Mechanization study programme at IPB had been fortunate to get the opportunity to pursue their Master's and PhD degrees in the USA under the Kentucky Contract Team Programme in 1957–1966, and the Midwestern University Consortium for International Assistance – United States Agency for International Development (MUCIA-USAID) programme in 1970–1981 which extended to 1988 (USAID, 1988). In the USA, the IPB faculty staff realised that they were studying AE, which had significant differences from Agricultural Mechanization in the curriculum course contents and degree recognition.

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In returning home, six US and one Japanese PhD alumni observed that they could restructure the existing Agricultural Mechanization curriculum into the AE curriculum and they could deliver AE engineering courses, so they decided to transform Agricultural Mechanization into an AE study programme, also changing the name of the faculty to the Faculty of Agricultural Technology in 1981.

It took about one generation of education (10–15 years) for other universities to follow the step since they were required to prepare a sufficient number of PhD faculty staff to manage the AE study programme by sending them either to the AE graduate programme at IPB University that had been initiated in 1979 or to AE graduate programmes abroad. Table 19.1 illustrates the transformation process at IPB and the other 16 universities offering AE/ABE in Indonesia. In the other universities, the changes from Agricultural Mechanization to AE study programmes happened in 1989 (STIPER Agricultural Institute), 1991 (Hasanuddin University), 1994 (Brawijaya University), 1995 (Sriwijaya University), 1996 (Andalas University, Gadjah Mada University, Padjadjaran University, and Sam Ratulangi University), and 1998 (Jember University).

When other universities established the AE study programme at a later stage (1995–2014), they did not start with Agricultural Mechanization but directly constructed the AE curriculum. An observation from Table 19.1 indicated that eight universities did exactly that: Udayana University and Lampung University in 1995, North Sumatra University in 1996, Syiah Kuala University in 1997, Soedirman University in 2000, Mataram University in 2005, and Jambi University in 2014.

By sending many of the faculty staff for AE PhD degrees abroad as early as 1974 who returned home in 1979–1980, the AE study programme of IPB University created AE graduates who worked at many universities in the provinces. After getting their PhD degrees either abroad or back at their alma mater at the AE graduate studies of IPB University, they set up the AE study programme at their universities. Out of the 16 other AE study programmes in Indonesia, the alumni of IPB played significant roles and leadership at about eleven universities.

The transformation from the AE into the ABE study programme at IPB University was unique because it took a stepping stone in the Mechanical and Biosystems Engineering study programme. In other universities, the transformation of AE into an ABE study programme proceeded directly. The process of transformation is still going on in Indonesia. In 2022, only six universities were transformed into the ABE study programme; another is under process (Table 19.1), while others have not yet fallen into a similar step. One of the reasons could be the limited number of PhDs they have, so they are waiting to complete their staff education abroad or at IPB University, Gadjah Mada University, or other national universities that have now offered graduate study.

In an infographic map, the current situation can be presented in Figure 19.1, illustrating the spread of the AE and ABE study programmes across provinces in Indonesia. The number marked on the map is the same number listed in Table 19.1 so the viewing of Figure 19.1 should be accompanied by looking at Table 19.1.

The map showed one of the big challenges faced by Indonesia in establishing quality education equally from island to island, from the western to the eastern part of the country. Indonesia consists of 34 provinces distinguished by different shades on the map (Figure 19.1). The government recently added 4 more provinces in Papua, the largest island (not yet appearing on the map), even though the population is the lowest among the five biggest islands in the nation. AE and ABE study programmes exist in 17 universities in 13 provinces located on the three bigger islands of Java, Sumatra, and Sulawesi, and the two smaller islands of Bali and West Nusa Tenggara. Agricultural engineers in Indonesia still have to work hard to extend the AE or ABE higher education to other universities in the provinces located in the other bigger islands of Kalimantan and Papua, and the smaller islands of East Nusa Tenggara and Maluku as well. Interestingly, only one private university – Stiper Agricultural Institute, Yogyakarta, DIY (Stiper, 2022) offers AE/ABE, while the 16 others are state universities.

Indonesia's National Accreditation Board for Higher Education accredits all university study programmes. Sixty-five per cent of Indonesia's 17 AE/ABE study programmes are accredited A, while others received accreditation B, and none got C. In 2014, the Mechanical and Biosystems Engineering Study Programme at IPB University took a further step to being accredited by JABEE (Japan Accredited Board for Engineering Education), a signatory member of the Washington Accord. The duration of accreditation is valid until 2019. After transforming into Agricultural and Biosystems Engineering, it obtained IABEE (Indonesia Accreditation Board Engineering Education) accreditation from 2020–2022. IABEE was accepted as a provisional signatory member of the Washington Accord in 2019 and as a full signatory member in 2022.

Definition of Agricultural Mechanization and ABE

Agricultural Mechanization in Indonesia was defined as a discipline of science that explores natural resources and energy for the development of human creativity in agriculture for the prosperity of human beings. The definition was formulated at the First Symposium of the Indonesian Association of Agricultural Mechanization Professions at Ciawi, Bogor, in 1967 (Setiawan et al., 2006, p. 1). Later, the association was transformed into the Indonesian Association of Agricultural Engineers (PERTETA), up to the present.

The definition of ABE is more varied among the ABE study programmes across the country. For example, IPB University defines ABE as a science in engineering and its applications for machinery and process modelling related to sustainable biological systems in food and agriculture (Teknik Pertanian & Biosistem IPB, 2022). Gadjah Mada University emphasises that ABE focuses on using engineering and management in biomass production to fulfil people's needs and maintain environmental sustainability (Departemen Teknik Pertanian dan Biosistem UGM, 2022). Furthermore, Brawijaya University describes ABE as the applications of production technology using agricultural products, materials, and natural power, emphasising the environment and the agricultural production and processing system (Teknik Pertanian dan Biosistem UB, 2022).

TABLE 19.1

The transformation of Agricultural Mechanisation to AE and ABE study programmes in universities in Indonesia.

No	Founded Study Programme, University, Year	Transformation 1, Year	Transformation 2, Year	Transformation 3, Year
1	Agricultural Mechanization, Faculty of Agriculture, Andalas University, Padang, West Sumatera, 1957	AE, Faculty of Agriculture, 1996	ABE. Faculty of Agricultural Technology, 2020	
2	Agricultural Mechanization, Faculty of Agriculture, Gadjah Mada University, Yogyakarta, DIY, 1963	Agricultural Mechanization, Faculty of Agricultural Technology, 1964	AE, 1996	ABE, 2020
3	Agricultural Mechanization, Faculty of Agricultural Mechanization and Technology, IPB University, Bogor, West Java, 1964	AE, Faculty of Agricultural Technology, 1981	ABE/Mechanical and Biosystems Engineering, 2010 *Accredited by JABEE from 2014-2019*	ABE, 2017 *Accredited by IABEE from 2020-2022*
4	Agricultural Mechanization, Faculty of Agriculture, Brawijaya University, Malang, East Java, 1974	AE, Faculty of Agriculture, 1994	AE, Faculty of Agricultural Technology, 1998	ABE, 2021
5	Agricultural Mechanization, Faculty of Agriculture and Forestry, Hasanuddin University, Makassar, South Sulawesi, 1980	AE, Faculty of Agriculture and Forestry, 1991	AE, Faculty of Agriculture, 2008	
6	Agricultural Mechanization, Faculty of Agriculture, Padjadjaran University, Bandung, West Java, 1983	AE, Faculty of Agriculture, 1996	AE, Faculty of Agro-Industrial Technology, 2005	
7	Agricultural Technology, Faculty of Agriculture, Jember University, Jember, East Java, 1983	AE, Faculty of Agricultural Technology, 1998		
8	Agricultural Mechanization, Faculty of Agriculture, Sriwijaya University, Palembang, South Sumatera, 1984	AE, Faculty of Agriculture, 1995		
9	Agricultural Mechanization, Faculty of Agriculture, Sam Ratulangi University, Manado, North Sulawesi, 1984	AE, Faculty of Agriculture, 1996		
10	Agricultural Mechanization, Faculty of Agriculture, Stiper Agricultural Institute, Yogyakarta, DIY, 1985	AE, Faculty of Agricultural Technology, 1989		
11	AE, Rector Office, Udayana University, Denpasar, Bali, 1995	AE, Faculty of Agricultural Technology, 2004	ABE, 2020	
12	AE, Faculty of Agriculture, Lampung University, Bandar Lampung, Lampung, 1995			
13	AE, Faculty of Agriculture, North Sumatera University, Medan, North Sumatera, 1996	ABE, Faculty of Agriculture, 2021		
14	AE, Faculty of Agriculture, Syiah Kuala University, Banda Aceh, DI Aceh, 1997			
15	AE, Faculty of Agriculture, Soedirman University, Purwokerto, Central Java, 2000			
16	AE, Faculty of Agriculture, Mataram University, Mataram, West Nusa Tenggara, 2005	AE, Faculty of Food Technology and Agroindustry, 2012	ABE, 2022 (under process)	
17	AE, Faculty of Agricultural Technology, Jambi University, Jambi, Jambi, 2014			

In comparison, the American Society of Agricultural and Biological Engineers (ASABE) mentions that ABE refers to the application of engineering science and designs to the processes and systems involved in the sustainable production, post-production, and processing of safe food, feed, fibre, timber, and other agricultural and biological materials, and the efficient (ASABE, 2022). Discussing the evolution of AE education into Biosystems Engineering education in Europe, Briassoulis et al. (2008) defined Biosystems Engineering as a science-based engineering discipline that integrates engineering science and design with applied biological, environmental and agricultural sciences, broadening in this way the area of application of engineering sciences not strictly to agricultural sciences, but to the biological sciences in general, including the agricultural sciences. This was repeated by Holden et al. (2020, p. vii) in an ASABE-published textbook stating that

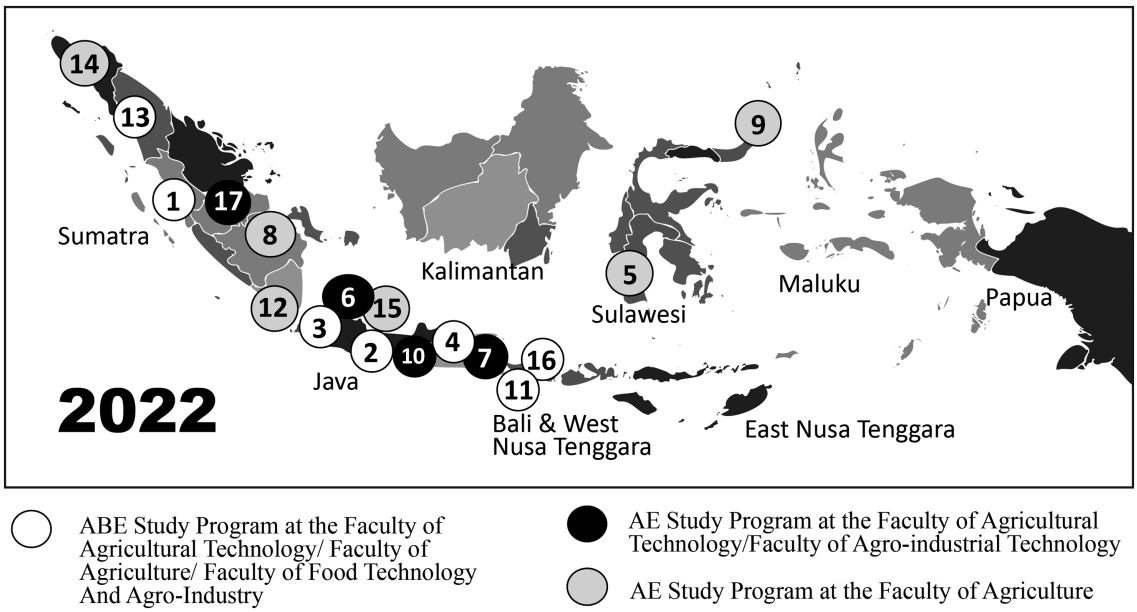

FIGURE 19.1 Map of universities offering Agricultural Engineering/Agricultural Biosystems Engineering (AE/ABE) Study Programmes in Indonesia in 2022.

Biosystems Engineering integrates engineering science and design with applied biological, environmental, and agricultural sciences.

The Development of Divisions in Agricultural Mechanization and AE/ABE Study Programmes

The development of divisions under Agricultural Mechanization and AE/ ABE study programmes in Indonesia is closely influenced by the visions of the faculty staff, the resources owned by the related university, the participation of the faculty staff in either the national or international cooperation programmes in agricultural development, the graduate education experienced by the faculty staff, and the development of AE/ABE in the world. The weight of the influential factors may not be divided equally, but they are connected. For example, the vision of the faculty staff will motivate them to find the resources needed to deliver good teaching and research and to find and participate in national and multinational programmes enhancing the agricultural programmes in Indonesia. Their graduate education experiences and the network they established while studying abroad or domestically support their motivation.

In 1978–1990, the JICA (Japan International Cooperation Agency) Programme significantly improved the education quality of the AE study programme at IPB by strengthening the resources and capacity building of the Faculty of Agricultural Technology, IPB University, including the AE study programme. The programme provided 10,000 m^2 of faculty buildings, laboratories, equipment, a pilot plant, and a massive graduate scholarship. As an alumnus of a Japanese university, the AE faculty staff, Dr Kamaruddin Abdullah – later a full professor – had been playing a key role in obtaining the JICA grant. It was also one of the major factors that motivated the decision to change from the Agricultural Mechanization study programme to the AE study programme at IPB in 1981 (Table 19.2), and the action helped support the AE-IPB as the trendsetter in the AE/ABE education development in Indonesia. This case was a model of how a visionary faculty staff was highly motivated to leverage his network into a significant multinational cooperation that fully benefited all.

National and multinational cooperation programmes in postharvest technology to develop grain and horticultural product postharvest machinery in Indonesia occurred a lot in the decade of 1980–1990. Early in the 1980s, the UNFPA project provided a programme to establish small soybean processing enterprises for homemakers in Java, Bali, and West Nusa Tenggara villages. An AE staff was involved in manufacturing tofu and tempeh processing machinery and helped the small plants operate as business entities. From the mid-1980s until the mid-1990s, AGPP (ASEAN Grain Postharvest Programme), later on broadened to ACPHP (ASEAN Crops Postharvest Programme) to also cover other crop commodities, GTZ, IDRC, and IRRI handed over several programmes to distribute out paddy threshers, maize shellers, soybean threshers, horticultural and tuber dryers, and paddy combine harvesters to provinces in Java, Sumatra, and Sulawesi. The projects involved not only AE faculty staff from IPB but also from Gadjah Mada University and Andalas University as well. The trend in the national development encouraged the IPB faculty staff of Food Technology and AE to form and open a new Master's degree in Postharvest Technology in 1983, led by the AE faculty staff as the Chair, which later on was put permanently under the AE study programme. The interest in this field was also indicated by several AE study programmes creating divisions of either Postharvest Engineering or Postharvest Technology at Andalas University, Udayana University, and most recently, Jambi University (Table 19.2).

The ABE study programme at IPB does not contain the Division of Soil and Water Engineering like in the other universities (Table 19.2) because the division moved to form a new

TABLE 19.2

Development of divisions in Agricultural Mechanisation, AE, and ABE study programmes.

University	Divisions of the Agricultural Mechanization Study Programme	Divisions of the AE Study Programme	Divisions of the ABE Study Programme
IPB	1964* 1. Farm Machinery 2. Agricultural Product Processing Machinery 3. Food Processing Machinery 4. Soil and Water Engineering 5. Farm Structure 6. Farm Electrification	1981 1. Farm Machinery Engineering 2. Soil and Water Engineering 3. Agricultural Mechanization System and Management 4. Food and Agricultural Product Processing Engineering 5. Energy and Electrification 6. Farm Structure and Environment 7. Agricultural Ergonomics and Electronics	2010 1. Mechanical Engineering and Automation 2. Biosystems Engineering 3. Renewable Energy Engineering 4. Bioinformatics Engineering
Other Universities	After 1964 1. Similar to IPB but selected divisions only 2. Modification of some selected divisions from Agricultural Mechanization IPB: 2.1. Farm Machinery and Equipment 2.2. Agricultural Product Technology 3. Unique divisions created by University: 3.1. Postharvest Engineering by Andalas University in 1974	After 1981 1. Similar to IPB but selected divisions only 2. Modification of some selected divisions from AE/ABE-IPB: 2.1. Farm Machinery and Equipment Design; and Farm Power and Machinery 2.2. Land and Water Resources Engineering 2.3. Management for Farm Machinery and Equipment; Management and Information System for Farm Machinery and Equipment 2.4. Agricultural Product, Food and Postharvest Engineering 2.5. Postharvest Technology 2.6. Thermal System and Renewable Energy Engineering 2.7. Bioinformatics and Information Engineering 2.8. Oil Palm Mechanization 2.9. Agronomy and Mechanization Technology 2.10. Agro-Informatics Technology 3. Unique Divisions created by Universities: 3.1. Instrumentation by Jember University in 1998; and Instrumentation and Control by Hasanuddin University in 2008 3.2. Bioprocess Engineering by Mataram University in 2005 3.3. Pre-Harvest Engineering by Udayana University in 2005 3.4. Environmental Engineering/Control and Conservation by Mataram University in 2005 and Jember University in 2011 3.5. Agricultural Energy, Automation, and Informatics by Jember University in 2011 3.6. Bio-Environmental Management and Control Engineering, and 3.7. Information and Agro-Industrial Engineering by Soedirman University in 2016 3.8. Farm Workshop by Syiah Kuala University in 2016, and Mechanical and Farm Workshop Engineering in 2020 3.9. Oil Palm Industrial Engineering, 3.10. Mechatronics and Agricultural Automation, and 3.11. Hortismart Technology by Stiper Agricultural Institute in 1985	After 2010 1. Maintain previous AE divisions 2. Modification of some selected divisions from AE-IPB: 2.1. Soil and Water Resources Engineering 2.2. Equipment Design and Ergonomics 2.3. Agricultural Engineering Management System 3. Unique Divisions created by Universities: 3.1. Biophysics by Gadjah Mada University in 2020 3.2. Natural Resources Management by Udayana University in 2020 3.3. Biosystems Mechatronics by Brawijaya University in 2021

* Andalas University, founded in 1957 with no division
Gadjah Mada University, founded in 1963 with two divisions: Farm and Agricultural Machinery; and Soil and Water Preservation Engineering

study programme, in Civil and Environmental Engineering, that was still under the Faculty of Agricultural Technology in the same time with the transformation of AE into ABE study programme in 2010.

Other Issues Addressed by AE-IPB University as the Trendsetter in the Education System

Higher education in Indonesia in the era after independence, around 1945, was still following the conventional system. Until 1980, undergraduate students experienced annual evaluations that would hand them the decision to pass or not pass to the next level. If the students were granted not pass, they had to repeat all courses at the same level they took previously regardless of the grade they gained for the courses. All the courses with grades A, B, C, D, to F were to be repeated, giving them a boring and frustrating load. This system caused many students to stay as recidivists as they were called for more than two years at one level, thus stacking up the number of students at every level, producing many dropouts, and lengthening the study duration unnecessarily. The ratio of output over input at the universities became small, and the cost of education was

high and had to be shouldered by the government since, at the time, students in state universities were free from tuition.

In 1981, the fresh PhD graduates returning from the USA to the AE study programme at IPB University observed that the lagging situation could not be further tolerated if the Indonesian higher education system wanted to emerge in an equal quality with other global universities. By chance, two of them were appointed as Dean and Vice Dean for Academic Affairs of the Faculty of Agricultural Technology, so they introduced the credit unit system evaluation every semester instead of an annual evaluation system. The credit unit system allowed the students to take new courses offered for the next semester, accepting the validity of A-, B-, and C-graded courses of the previous semester not to be repeated. However, students had to repeat the D- and F-graded courses from the previous semester in addition to the new courses. The new system also cut the internship from two times to one time, trusting in one high-quality experience rather than in quantitative numbers. The internship moved to the end of the 6th instead of the 7th semester, avoiding conflict with the research manuscript preparation, starting early in the 8th semester.

Many, including the IPB rectorate office, were opposed to the initiatives, thinking that they required a good computer system which was still scarce at the time, but it was proven successful even though it operated manually. Surprising to many people, some of the first batch students exposed to this system could finish their BS-AE degree in seven semesters or 3.5 years, another advantage of this kind of system. When IPB University, as a whole, adopted the credit unit system, it was broadly followed by other universities in Indonesia, improved, and much later computerised. Before long, as everybody realises, the credit unit system, called SKS, is now adopted as a natural part of the Indonesian higher education system as in other universities in the world.

The Curricula of the AE/ ABE Study Programme

The AE/ABE study programme for undergraduates in Indonesia is 4 years of study consisting of 8 semesters. Febo and Comparetti (2013, pp. 2–3) and Comparetti and Febo (2018) note that in Europe, the length of study for the ABE programme is planned to be 3 years, called pivot-point. This means the European ABE BS system will have a one-year advantage. It further impacts the MSc education system for ABE. In Europe, an MSs in ABE can be completed in 3 + 2 years, while in Indonesia it takes 4 + 2 years. No information is available on whether the US education system will shorten the 4-year BS degree. However, the difference with the Indonesian education system is that the US system does not include research in the BS study programme.

The structure of the AE/ABE curricula, in general, can be presented as listed in Table 19.3 taking an example of ABE curricula at IPB University (Widodo & Supriyanto, 2020). The terms and the total credits for the undergraduate programme may be slightly different from one university to another university, however, the principles are similar.

TABLE 19.3

The structure of ABE curricula at IPB University (Widodo & Supriyanto, 2020).

No	Element	SKS	Percentages
1	Common and Fundamental Courses	36	24.5
2	Core (Engineering) Courses	36	24.5
3	In-Depth/Competencies Courses	30-31	21.0
4	Enrichment Courses	22	30.0
5	Final Projects	22	30.0
	Total	146-147	100.0

The core engineering courses included i. Engineering Drawing, ii. Engineering Mechanics, iii. Strength of Materials, iv. Measurement and Instrumentation, v. Fluid Mechanics, vi. Engineering Thermodynamics, vii. Heat Transfer, viii. Electricity and Electronics. This has similarities with the core engineering courses listed by Briassoulis et al. (2013, p. 310), i.e., i. Engineering Graphics and Design (CAD), ii. Mechanics (Statics), iii. Strength of Materials, iv. Mechanics (Dynamics), v. Fluid Mechanics, vi. Applied Thermodynamics, vii. Heat and Mass Transfer, viii. Electricity and Electronics, and ix. System Dynamics.

The Final Projects may include several courses and projects allocated in Semesters 7 and 8. The courses are usually the capstone courses such as Engineering Design and Agricultural Machinery and Equipment Design. The projects may cover Engineering Design Project, Research Manuscript, which is an undergraduate research report, Seminar on Research Proposal, Seminar on Research Results, and Scientific Publication.

Two curricula of the ABE Study Programmes are selected to represent AE/ABE education in Indonesia in general. First, from the IPB University, Bogor, West Java, as the trendsetter of AE and ABE development in the nation, and the second is from Udayana University, Den Pasar, Bali, which is relatively newly founded and developed but already has an ABE Study Programme. The curricula of the ABE Study Programme for undergraduates at IPB University are presented in Table 19.4 (Widodo & Supriyanto, 2020). The curricula of the ABE Study Programme for undergraduates at Udayana University, Denpasar, Bali are presented in Table 19.5 (Wirawan et al., 2022).

Current Research in AE/ABE Integrated with Emerging Technology

Research is carried out by the faculty staff and intertwined with undergraduate education. In the universities offering graduate courses, research is part of the education system from undergraduate to graduate. In 2022, out of the 17 universities with AE/ABE study programmes, three offer MSc and PhD graduate study: IPB University at Bogor, West Java, Gadjah Mada University at Yogyakarta, DIY, and Padjadjaran University at Bandung, West Java. Three other universities offer only MSc graduate study: Andalas University at Padang, West Sumatera; Brawijaya University at Malang, East Java; and Hasanuddin University at Makassar, South Sulawesi.

TABLE 19.4

Curriculum of the ABE Study Programme at IPB University, Bogor, West Java (Widodo & Supriyanto, 2020).

No	Courses	SKS*	No	Courses	SKS
Semester I			**Semester II**		
1	Pancasila (Indonesian Way of Life)	2	1	Religion	3
2	English	3	2	Indonesian Language	2
3	Introduction to Mathematics	3	3	Introduction to Agriculture	2
4	Biology	3	4	Calculus	3
5	Physics	3	5	Chemistry	3
6	General Sociology	3	6	General Economics	3
7	Introduction to Entrepreneurship	1	7	Introduction to Agricultural Technology	2
	Total	**18**		**Total**	**18**
No	**Courses**	**SKS**	**No**	**Courses**	**SKS**
Semester III			**Semester IV**		
1	Principles of Agronomics	3	1	Surveying	2
2	Calculus II	3	2	Fluid Mechanics	3
3	Engineering Mechanics	3	3	Engineering Mathematics	3
4	Engineering Materials	2	4	Engineering Drawing	3
5	Workshop	3	5	Strength of Materials	2
6	Engineering Characteristics of Agricultural Materials	2	6	Engineering Thermodynamics	3
7	Engineering Programming	3	7	Automatic Control	3
8	Measurement and Instrumentation	3	8	Engineering Statistics	3
	Total	**22**		**Total**	**22**
No	**Courses**	**SKS**	**No**	**Courses**	**SKS**
Semester V			**Semester VI**		
1	Engineering Hydrology	3	1	Engineering Entrepreneurship	1
2	Machine Elements	3	2	Farm Machinery and Equipment	3
3	Integrated Laboratory Practices: Engineering Mechanics and Materials	1	3	Irrigation and Drainage Engineering	2
4	Engineering Economics	3	4	Agricultural Product Processing Engineering	2
5	Heat Transfer	2	5	Agroindustry Management	3
6	Engine and Driving Power	3	6	Energy and Farm Electrification	3
7	Farm Structure and Environment	2	7	Scientific Writing and Presentation Methods	1
8	Agricultural Mechanization System and Management	3	8	Greenhouse and Hydroponics Technology	2
			9	Elective 1	2-3
	Total	**20**		**Total**	**19-20**
No	**Courses**	**SKS**	**No**	**Elective Courses**	**SKS**
Semester VII			**Semester VI**		
1	Food Process Engineering	3	1	Principles of Biosystems Process Engineering	2
2	Engineering Design	2	2	Ergonomics and Work Safety	3
3	Agricultural Machinery and Equipment Design	3	3	Agricultural Informatics Engineering	2
4	Integrated Laboratory Practices: Biosystems Environmental Control Engineering	1	4	Refrigerated Engineering	3
5	Postharvest Engineering	2	**Semester VII**		
6	Thematic Community Services	3	1	Robotics Engineering	3
7	Seminar on Research Proposal	1	2	Relationship of Soil and Farm Machinery and Equipment	3
8	Elective 2	3	3	Renewable Energy Conversion Engineering	3
9	Elective 3	3	4	Audit Energy	3
	Total	**21**	5	Supporting Course from Other Study Programmes	3
Semester VIII					
1	Research Manuscript	6			
	Total	**6**			
	Grand Total 146-147 SKS				

*SKS: *Satuan Kredit Semester* (Semester Credit Unit)

TABLE 19.5

Curricula of the ABE Study Programme at Udayana University, Bali, Denpasar (Wirawan et al., 2022).

No	Courses	SKS*	No	Courses	SKS
Semester I			**Semester II**		
1	Indonesian Language	2	1	Soil Biophysics	3
2	Social Science and Cultural Principles	2	2	Thermodynamics	2
3	Introduction to Agricultural Technology	2	3	Engineering Materials	2
4	English	2	4	Fluid Mechanics	3
5	Pancasila (Indonesian Way of Life)	2	5	Statistics	2
6	Mathematics	2	6	Heat Transfer	2
7	Physics	2	7	Engineering Mechanics	2
8	Climatology	3	8	Agricultural and Biosystems Science	3
9	Biology	2	9	Calculus	2
10	Chemistry	2			
	Total	**21**		**Total**	**21**
No	**Courses**	**SKS**	**No**	**Courses**	**SKS**
Semester III			**Semester IV**		
1	Engineering Drawing	2	1	Principles of Programming	2
2	Workshop	3	2	Engineering Economics	2
3	Electronics	3	3	Experimental Design	2
4	Strength of Materials	2	4	*Subak*** Irrigation Engineering	2
5	Hydrology	2	5	Land Surveying	2
6	Measurement and Instrumentation	3	6	Energy and Electrification	3
7	Machinery and Implements	2	7	Food Process Engineering	3
8	Irrigation and Drainage Engineering	2	8	Engineering Design	2
9	Engineering Mathematics	2	9	Power and Combustion Engine	2
			10	Integrated Irrigation Laboratory Practices	2
	Total	**21**		**Total**	**22**
No	**Courses**	**SKS**	**No**	**Courses**	**SKS**
Semester V			**Semester VI**		
1	Scientific Method	2	1	Smart Farming	3
2	Research Operations	2	2	System Dynamics	3
3	Mechatronics	3	3	Entrepreneurship	3
4	Supply Chain Management	2	4	Internship	3
5	Quality Management System	3	5	Elective 1	3
6	Geographical Information System	2	6	Elective 2	3
7	Greenhouse and Fertigation Engineering	3	7	Elective 3	3
8	Physiology and Postharvest Engineering in Horticulture	4			
	Total	**21**		**Total**	**21**
Elective Courses for Semester VI					
No	**Elective Courses**	**SKS**	**No**	**Elective Courses**	**SKS**
1	Remote Sensing	3	10	Refrigerated and Freezing Engineering	3
2	Multivariate Analysis	3	11	Drying Engineering	3
3	Farm Land Conservation	3	12	Packaging Engineering	3
4	Soil, Water, and Crops Relationship	3	13	Estate Crops Processing Engineering	3
5	Ergonomics and Work Safety and Health	3	14	Fishery Product Processing Engineering	3
6	Farm Environment and Biosystems	3	15	Agricultural Product Processing Engineering	3
7	Energy Conversion Engineering	3	16	Fresh Product Retail	3
8	Energy Audit	3	17	Supply Chain Analysis	3
9	Waste Processing Engineering	3			
No	**Courses**	**SKS**	**No**	**Courses**	**SKS**
Semester VII			**Semester VIII**		
1	Religion	2	1	Seminar on Research Results	1
2	Civics	2	2	Scientific Publication	1
3	Research Proposal	1	3	Research Manuscript	4
4	Community Services	3	4	Research Manuscript Exam	1
5	Major Design Project	5			
	Total	**13**		**Total**	**7**
			Grand Total 147 SKS		

*SKS: *Satuan Kredit Semester* (Semester Credit Unit)

***Subak* is a traditional Balinese irrigation system attached to the community culture and life

Emerging technologies such as AI, IoT, robotics, control and automation have been applied and integrated into Indonesia's current AE/ABE research. With the emerging technologies, the AE/ABE study programmes have taken steps to improve the laboratory facilities and equipment to conduct qualified research. Each university has its research roadmap conforming to national and provincial agricultural and economic development. In general, the coverage of research will be influenced by the interest of the faculty staff, taking into consideration their opportunity: i) to get the research funding from the Ministry of Education and Research, ii) to build cooperation with other parties such as regional government, industries, farmer or other user communities, and international institutions, and iii) to obtain access to appropriate instruments and equipment for running the experiments.

To observe the ongoing research implemented in AE/ABE education in Indonesia, two examples are provided: the ABE-IPB and Gadjah Mada Universities, both offer MS and PhD degrees added with Brawijaya University, which offers an MS degree only. ABE Study Programme at IPB University has four divisions as follows. The Division of Mechanical Engineering carries out research in technology applications to increase plant productivity through the development of biosensing, system monitoring, and variable rate control. Research themes, among others, are 1) the development of portable sensing instruments for non-destructive quality evaluation of agricultural products, 2) the development of machinery, robotics, and control systems for plant factories, 2) the development of precision machinery for the mechanisation of oil palm plantations, and 3) the development of machinery for food crops and terramechanics.

The Division of Biosystems Engineering works in a broad spectrum of research topics starting with 1) non-destructive quality evaluation for horticultural products, and estate crops using process imaging, Near Infrared Reflectance, and Ultrasonics, 2) design of packaging material and system for the distribution of perishable fresh agricultural products, 3) smart greenhouse and its control system, 4) the improvement of the parboiled rice process, 5) physical characteristics and process of Nano fibril soy protein, 6) microencapsulation of essential oil, 7) valorisation of whey protein, 8) development of fishing gear, 9) application of fine bubble technology for agri-aqua farming, and 10) plasma fine bubble technology for postharvest handling of agricultural products.

Division of Bioinformatics Engineering focuses on developing and improving PRECIPALM (Precision Agriculture Platform for Oil Palm) to predict the soil's content of N, P, K, and Mg. Data of the oil palm plantation area was extracted from the images captured using remote sensing Satellite Sentinel 1 and 2 with a multispectral camera and then inputted to the AI model producing real-time nutritional distribution in a colourful regional gradation spatial map indicating respected nutrition content. The map is useful for identifying the type of fertiliser and its total needs calculation in planting oil palm trees in the region. PRECIPALM has been developed in cooperation with East Kalimantan Fertilizer Factory and has gained copyright for 50 years from the Ministry of Law and Human Rights. Further, the division is looking for the application of AI and precision agriculture to predict the Basal disease attacking the oil palm and to estimate the production of the oil palm plantation.

The Division of Renewable Energy Engineering concentrates on the following fields: 1) thermo-chemical processing of biomass focusing on macroalgae and microalgae, 2) biofuel, biomass, and biohydrogen technology by exploring the system design and identifying the raw materials to produce the biofuel and biohydrogen, 3) thermal system simulation, modelling, and applications of heat pumps, solar flat plate collectors, biodiesel reactors, and biomass grate furnaces, 4) development of energy efficient solar drying, fluidised and rotary bed drying systems, and 5) energy and exergy analysis for the process of palm oil waste products into energy.

Research at the ABE Study Programme at Gadjah Mada University (*Departemen Teknik Pertanian dan Biosistem UGM*, 2022) is classified into four divisions. The Division of Land and Water Resources Engineering explores research in the fields of 1) the development of food production areas based on precision farming, 2) the modernisation of land and water resources management to support the sustainable growth of agriculture, and 3) the development of CSA-Climate Smart Agriculture to mitigate the climate change and to increase the agricultural productivity.

The Division of Biosystems Mechanical Engineering focuses on 1) the development of mechanisation system 4.0 with the orientation for humanised technology to create smart food estates, 2) the design of automated farm machinery that is based on the application of precision agricultural technology, and 3) the development of biomass energy as the source for the renewable energy to support the sustainable agricultural growth.

The Division of Food, Postharvest, and Bioprocess Engineering does research in 1) controlled postharvest handling technology to improve the quality and minimise losses of the agricultural products, 2) the implementation of the automated system for the machinery and equipment to support the food processing industry, and 3) the application of bioprocess technology through the chemical and biochemical design in food industry planning and management.

The Division of Biological Environment Control Engineering observes in-depth the following topics: 1) the design and utilisation of smart greenhouse technology to support the growth of environmentally friendly agriculture, 2) the development of controlled farm structure and environment to improve the quality and yield of the agricultural products, and 3) biomass agricultural waste handling technology to increase the value added of the agricultural system and to support the sustainable agriculture.

Research and development at the ABE Study Programme, Brawijaya University, Malang, East Java, also cover four divisions. The Division of Farm Power and Machinery develops agricultural machinery design and performance testing, biodiesel processing systems with ultrasonic, biodiesel processing using the supercritical reactor and continuous supercritical reactor, the purification of bioethanol to achieve fuel grade quality, the production of hydrogen energy, and low-temperature seed drying systems.

The Division of Food and Agricultural Product Processing Engineering explores a broad spectrum from the drying

kinetic and physical characteristics of specific agricultural products such as the flower of *Clitoria spec* L. for herbs and the fruits of *Pangium edule* Reinw. ex Blume for foods, and the seeds of *Sapindus rarak* for traditional detergent; the design of solar and solar hybrid dryers; new inventions in vacuum frying systems; hypobaric storage of fruits at low temperatures; the application of electric field pulses for milk and fruit juice pasteurisation; non-destructive quality evaluation of oil palm fruits and horticultural products; the biopolymer and bioceramic based membrane synthesis for food processing and production of new biomaterials from waste products; to bioplastic processing from root crops.

The Division of Biosystems Mechatronics consists of bioinstrumentation, control, and system engineering in a plant factory, a fully controlled closed bioproduction system using plant response-based sensing, and the application of IoT and AI in optimisation modelling in agricultural engineering problems. Some topics, for example, are the use of computer visions and Artificial Neural Networks to control plant water content and plant nutrition based on the Speaking Plant Approach; smart greenhouse design and control; the use of photonics engineering, chemometrics, and machine learning for plant diseases detection, quality evaluation, and fruit grading and sortation; and the development of bio-sensing instrumentation for non-destructive quality evaluation.

Division of Natural Resources and Environmental Engineering focuses on irrigation engineering such as sprinkle irrigation, sub-surface irrigation, drip, and trickle irrigation; and land and water conservation, as well as environmental conservation at the watershed area.

In comparison with the ABE divisions in the three universities in Indonesia, it will be worthwhile to look at the ABE study programme in Europe and US. Briassoulis et al. (2013, p. 310) indicated that there are six specialisations incorporated as the mid-level competencies in a Biosystems Engineering study programme in Europe: Bioprocess Engineering; Bioenergy Systems; Bio-based Materials; Biosystems Informatics and Analysis; Structural Systems, Materials, and Environment for Biological Systems; and Water Resources Engineering.

Ting (2010, pp. 1–2) analysed the core competencies in Biological/Biosystems Engineering in the US from four major areas: Automation, Culture, Environment, and Systems. When these four major areas intersect, they will breed emerging ABE disciplinary relevance and impact areas. Many are similar to the previously mentioned areas, and more, such as Biomass and Renewable Energy; Precision and Information Agriculture; Agricultural and Biosystems Management; Food Quality and Safety; Spatially Distributed Systems; Bio-sensors; Bionanotechnology; and Intelligent Machinery Systems.

Unique Initiatives Applied in AE/ABE Education

Substituting Internships for Real Experience in Farming and Postharvest Processing

The internship has been interwoven with the Agricultural Mechanization curriculum since it was first offered as a study programme in 1957. It went along with the transformation of Agricultural Mechanization to AE and ABE curricula. Accounted to 3 SKS, a student will go for an internship in food and agricultural industries such as beverages plants, food canning factories, and agricultural machinery manufacturers; in plantations of estate crops such as oil palm, rubber, tea, coffee, cocoa, and tobacco; and in watershed management authority institutions for 1–3 months. During this period, the students are obliged to do the internship under the company's direction and write reports afterwards approved by the company and their academic advisers.

Challenges happen when some industries, plantations, or offices that traditionally are willing to accept internship students decline to do so at one time for any reasons that maybe occur in their internal management. With an average of 100 students per batch per university, the faculty staff is pressured to help all students find a good internship programme simultaneously at a representatively sized company or institution. It should be noted that the time for internships is the same for all universities, i.e., at the end of the even semester every year.

Hence an alternative idea: the notion of offering the students to practice farming and postharvest processing on campus land instead of going to industries was considered interesting. The idea was implemented in an even semester of the year 1986. Students were divided into ten people per group, and each group determined the seasonal crop they wanted to plant, like maize, soybeans, mungbeans, and groundnuts. They developed a plan from planting to postharvest processing until marketing, implementing their knowledge using the agricultural machinery provided by the university for land tillage, seed planting, water irrigation system, threshing, and drying. Observing how each group solved the problems they faced during the practices was worthwhile for the students and the faculty staff. This interesting idea would be adopted, except the students did not have enough time because the internship should be completed over three months before the next semester began. Since the crop harvest was done only after three months, the students needed longer to do postharvest processing and marketing. They, unfortunately, had to do that overlaid with the new courses in the next semester. Thus, this interesting and beneficial alternative was dropped and never applied anymore.

Intensive Homework and Quizzes for Challenging Courses

Undoubtedly, the engineering curriculum contains mathematics and courses loaded heavily with mathematics. Students need to practice problem-solving in these kinds of courses. To facilitate the students, these courses provide intensive homework given at every class meeting, evaluated by the faculty staff immediately, returned to the students, and discussed at the next class meeting. To maintain students' interest and concentration, the delivery time is limited to two hours each 50 minutes, so courses with 4 credits will be divided into two class meetings in one week, each in two hours. Instead of providing the student with a two-time evaluation at the middle and the end of the semesters, the courses conduct 5 times of quizzes, breaking the course materials into 5 equal-load sections and evaluating each time after each section.

The initiative proved to be successful in leveraging the students' knowledge, indicated by the higher grades gained by the students. The courses are removed from the students' "killer courses" list, and they feel a lot easier when taking them. The challenge is finding the faculty staff willing to do extra time to evaluate the homework consisting of 5 problems twice a week for an average of 100 students, plus the additional 3 times more quizzes equal to mid-term and final semester exams. It is unfortunate that after being implemented for about 30 years, the initiative has been removed since the study programme could not find any more faculty staff willing to spend extra time after the retirement of the initiator.

Encouraging Students to Initiate a Startup

As far back as June 1997, when the world monetary crisis happened and hit Indonesia very hard, not only in the national economy but also in socio-politics, the opportunity for university graduates in Indonesia to find a job steeply decreased. It was intensified because the IDR conversion to USD depleted to one-eighth in a short time, leaving a traumatic shock to everybody with increasing flaring inflation.

Fortunately, just before the monetary crisis, the AE study programme had started offering the Entrepreneurship course in semesters V, VI, or VII. It was also doubly lucky that the Ministry of Education and Culture provided a national programme encouraging groups of students to initiate a startup, awarding them little seed money but sufficient, and competitively based on a selection of their business proposals.

The Entrepreneurship course might replace the mid-term and final semester evaluation with the business proposal developed by the students per group of four. The business proposals were then submitted to the Ministry of Education and Culture to be selected for a seed money grant. Out of an average of 25 proposals submitted annually, the AE/ABE students at IPB University successfully obtained 16 startups to be funded. Once the students gained the seed money, they started the business. Some startups were successful, and some failed. However, the important thing was that students had experience in doing commercial business, which could become another alternative for a career after graduation. The initiative established at the end of the 1990s has been adopted continuously until now.

Providing an Alternative To the Research Manuscript

It has been narrated in the previous sub-chapter that Indonesian BS curricula covers 8 semesters in 4 years and includes research in the Final Project in Semester VIII, called the Research Manuscript (Table 19.4). It has been compared to the recent European education offering a 3-year bachelor programme, and the US system with a 4-year bachelor without research. Some universities in the Philippines have taken the same move as in Europe. Japanese undergraduate programmes still adopt research as the final assignment for the students. In Australia, students who do not take BS for Honor do not need to complete research. Undoubtedly, the BS for Honor is prepared for students who want to continue into advanced studies. Overall, it could be concluded that in the Asian continent, there are many universities applying research as part of the BS curriculum.

The controversial issue is that research for the BS study programme only benefits the graduates who plan to continue for their advanced degree and work in research and research-related institutions like consultant offices, NGOs, and Research & Development units in the industries. However, several attempts by visionary faculty staff in Indonesia to cut research as a compulsory project for a BS degree have not been fruitful, and neither is the cut of a 4-year study into a 3-year study.

In light of the situation, initiatives have been applied to provide alternatives to the Research Manuscript. One is to allow students to intern in a startup company for three months, advised by the academic adviser and the business incubator management in the university where the startup company is taken as the resident incubatee. The first trial in 1989 at IPB University proved to be successful. Ten students from semester VIII who originated from several different study programmes were registered under this programme, interned at the startups, and wrote a manuscript about the commercial business operation of the startups as the final assignment. Even though the alternative is still provided, not many students enrol in this one. The in-depth observation indicated that most faculty staff encourage undergraduate students to do research.

The reason is that the faculty staff needs research to fulfil the requirement necessary for their annual performances evaluated by the university and the Ministry of Education, Culture and Research Technology. The accumulative points of performance that include research, scientific publications, writing books, teaching, and community services are the means for faculty staff to climb to a higher level of career until reaching the peak as a professor. Since the number of graduate students is far too low compared to the number of undergraduates, the convenient way out is to involve the undergraduate students as well in doing research.

New Initiative by the Ministry of Education, Culture and Research Technology

In 2020, the New Minister of Education, Culture, and Research Technology, who supervised both state and private universities, introduced the Independent Learning-Independent Campus (MBKM) system, meaning every university student is free to choose the eight education channels offered in the programme based on the student's passion and interest for either one or two semesters given quite a generous credits of maximum 20 SKS per one semester and 40 SKS per two semesters (*Direktorat Jenderal Pendidikan Tinggi*, 2020). Except for an education channel called the Students Exchange channel, the system further means the student may replace 7-8 core courses per semester in the student's curricula with one of the other seven channels in the programme. The eight channels are as follows.

1. Student Exchange: Student Exchange allows students to enrol for one semester in other universities taking similar courses to the original courses in their study programme's curricula or to enrol in other study programmes in the same university taking different courses from their study programme's curricula.

2. Internship: A channel opens for students to intern in industries for one full semester. There are two alternatives called free-form and structured form. In the free-form, the host industries evaluate the students for various components agreed upon by both the industry and the students before the internship. In the structured form, the lecturer from the core courses replaced by the internship will grade the students' performances during the internship.
3. Teaching Assistantship: The Teaching Assistantship channel allows students to become assistants in teaching at the following levels: elementary school, junior, and senior high school. This channel is specifically provided for study programmes in education, resulting in the graduates' profession as a teacher in elementary and high schools.
4. Research Assistantship: Research Assistantship is a channel provided for students who have a passion for research and plan to have a career as a researcher. The duration can be taken for one or two semesters. Research assistantships can be carried out in research institutions and study centres.
5. Humanity Project: This channel allowed students to join national or international humanity projects as foot soldiers such as pioneering natural disaster relief and refugee handling projects in one or two semesters.
6. Entrepreneurship Programme: The university offering this channel has made it compulsory to develop an overall entrepreneurship programme of 20 SKS with detailed structures constituting an integrated programme that may cover the micro-credential courses and the project setting up a startup. For this specific programme, the Ministry identifies and selects partner institutions that are trusted to have more practical skills in delivering the entrepreneurship programme. Students could select the partners identified by the Ministry or other plans set up by their university.
7. Independent Study/Project: Independent Studies/Projects are specific projects based on innovative ideas by a group of students from interdisciplinary studies participating in specific international competitions such as in science, engineering, law, or business. The other alternative is the independent project created by the study programme that has an innovative idea to support the student's education.
8. Villages Development/Thematic Community Services: This channel extends thematic community services in many university curricula for all study programmes. Students stay in the villages, living in the middle of the community, identifying the community problems, finding a solution, and implementing it. The usual 3 SKS thematic community services for 3 months now can be extended into 20 SKS for one semester or 40 SKS for two semesters. The Ministry encouraged the university to form cooperation with the Ministry of Villages, Disadvantaged Regions, and Transmigration for this specific channel.

The Ministry has socialised and promoted the new initiative starting in 2020. It grants higher KPI (Key Performances Index) for universities with more students involved in the new initiative. High incentives are given for students joining the eight channels in the programme initiation in 2020. Unfortunately, the incentives are decreasing in subsequent years as it becomes more likely to be integrated into the curricula by all universities compared to the initial year in 2020.

Some challenging issues that may be arisen during the full implementation of the new initiative in years ahead are the following.

1. Since most universities execute the timing of the new initiative programme in semesters V, VI, and VII, it means that a student joining the new initiative will replace either basic or core expertise courses that characterise the study programme commonly allocated in those semesters with the choice of the student's interests. The student may gain good skills from one of the eight channels but also loses part of the expertise foundation required to build the competencies of the related study programme.
2. The readiness of universities and lecturers varies in accepting students from other universities to attend the same courses they are interested in on the Student Exchange channel. Universities with a large student body will face a tough challenge in coordinating the time, classes, and lecturers when additional students are coming in a massive number. As a result, they may decline the option to host the Student Exchange.
3. Big universities in Indonesia may accept 100–300 students for each study programme annually. The critical factor is the capability of each study programme in managing this number of students to select different kinds of the eight programme channels. This may result in the limitation of offering only one or two of the eight related channel options.
4. The decreasing incentives for the students, after a good one in the initiation period of 2020, may discourage many from joining the new initiative afterwards.
5. Students taking the Student Exchange and Entrepreneurship channels by attending courses in excellent far-away universities or partner institutions did not have problems from 2020 to the middle year of 2022 because the classes are conducted online. After the pandemic subsided, students will face difficulties in supporting their living and travel far away to the host universities or partner institutions to attend conventional classes, except online classes remain offered by the hosts.
6. The principles of the Ministerial initiative are to provide freedom for university students to choose how to build their competency according to their passion and interests. However, the Ministerial system of granting higher KPI (Key Performances Index) to the universities with higher numbers of students joining the initiative programmes may contradict the

initiative's independent philosophy because it may motivate the universities to pressure students to join the programme.

The Contribution of ABE Graduates to Indonesia and the World

From 1957 until now, the total number of bachelor graduates in Agricultural Mechanization and AE/ABE study programmes from around Indonesia is estimated at over 25,000. Many of the graduates worked at government institutions such as the Ministries of Agriculture; Forestry; Marine Affairs and Fisheries; Education and Culture; Cooperatives and SMEs; Industry; Economics; Internal Affairs; Foreign Affairs; Law and Human Rights; the Investment Coordinating Board, the National Research and Innovation Agency (BRIN); and Regional Governments. Some are elected to legislative seats as members of the House of Representatives. In 65 years, some took the highest-level position, like the Minister of Agriculture (refer to Box 19.1), a province governor, or a career that looked as unlikely in the ABE profession as the Director General and Inspector General of the Min. Law and Human Rights, however, climbing from the Directorate of IPR (Intellectual Property Rights) was at least an indirect connection with the agricultural machinery design.

BOX 19.1: DR H. ANDI AMRAN SULAIMAN

Dr. IR. H. Andi Amran Sulaiman, M.P., the Minister of Agriculture, Republic of Indonesia in the cabinet period of 2014–2019, graduated as an Agricultural Engineer in 1993 from the Hasanuddin University, Makassar, South Sulawesi. He continued his studies to gain a Master's degree in 2003 and a Ph.D. in 2012 (Wikipedia, 2022b).

In his early career, he worked at the plantation state company of PT Perkebunan Nusantara XIV. He then quit the job and built his own company that expanded fast. His business became a holding company, Tiran Group, that covers 11 business enterprises such as rodenticide production, sugar cane, and oil palm plantations, sugar cane factory, distributors of food and other products, and mining in gold and nickel. As a creative businessman, he patented a rodent fogger with Patent No. ID S000001297 that later became commercially produced.

He has been very keen on leveraging the development of agricultural engineering professionals, and he assumed the Chair of the Association of Agricultural Engineers for South Sulawesi Province, Indonesia from 2006–2014.

He was appointed and served as a dedicative Minister of Agriculture under the Working Cabinet of President Joko Widodo, Republic of Indonesia in 2014–2019. Currently, on the 23rd October 2023 he was appointed again as the Minister of Agriculture until 2024.

In the early development, when the universities in Indonesia were still growing and expanding from the central government to the provincial capitals, many alumni of agricultural engineering filled up the needs of faculty staff in the newly established Agricultural Mechanization and AE/ABE study programmes across the country. The Department of Agricultural Mechanization IPB and Gadjah Mada Universities, as patriarchs, bred first generations of faculty staff assisting the foundation of many AE/ABE study programmes at the state universities in the provinces. When the postgraduate studies came to the education systems in agricultural engineering, the majority of the alumni working as faculty staff in the state universities went back to their alma maters (IPB and Gadjah Mada Universities) and pursued advanced degrees at the MSc and PhD levels. Some of the fortunate alumni followed the models of their professors to apply to various outstanding universities abroad to get their Master's and PhD degrees.

The continuing education in AE/ABE undergraduate and graduate programmes from generation to generation has been breeding distinguished full professors who produced successful graduates who later on gained full professors for themselves, and these later generations of professors have also educated their graduates who now have achieved full professors as well. Thus, three consecutive generations of full professors are now teaching AE/ABE in the universities in 13 out of 38 provinces in Indonesia. One of them is Prof. Dr Bayu Taruna Widjaya Putra, ABE Study Programme at Jember University, Jember, East Java, who was ordained as a full professor at 38 (Box 19.2). So far, he has been the youngest ABE professor in Indonesia.

BOX 19.2: PROF BAYU TARUNA WIDJAJA PUTRA

Prof Dr. Bayu Taruna Widjaja Putra is the youngest ABE Professor in Indonesia so far. He achieved his full professorship at 38 years of age in December 2022. He has published over 16 scientific articles, seven of them at Q1 Scopus level journals in the last five years. He is deeply committed to teaching and research. He wrote four books in Bahasa Indonesia (Indonesian language) on the ABE emerging technology to facilitate student learning.

His research focuses on photogrammetry and remote sensing, precision agriculture, AI, and deep and machine learning. As the leader, he makes a lot of improvements in the Laboratory of Precision Agriculture and Geoinformatics, ABE Department at Jember University, Jember, East Java.

Bayu wrote a book chapter, "Smart food sensing and IoT technology", in a book entitled *Bio- and Nano-Sensing Technology for Food Processing and Packaging*, published by the Royal Society of Chemistry in 2022. He has received international recognition from the KWEF (Kurita Water Environment Foundation), Japan as the

best researcher in 2019. He also obtained a credential as a Deep Learning Professional from PyImageSearch Raspberry Pi for Computer Vision in 2021.

He is an active fellow member of several international professional organisations such as IEEE and ISPRS. He is nominated as the country representative of Indonesia in ISPA (International Society of Precision Agriculture).

He graduated from AE Study Program at Jember University, and received his M.Eng. and Ph.D. degrees from the Agricultural System and Engineering Department, AIT, Bangkok, Thailand.

Some significant portion of graduates ventured into the private sector and state companies, spreading out a broad interest from plantations, agricultural machinery manufacturers, food and beverage industries, various types of industries outside agriculture, banks, retail, and restaurants, on to as far as the automotive industry. Some built their dreams of opening enterprises, being licensed by multinational corporates, or becoming inventors of their startups. They proliferated in the big cities but were also rooted in small villages doing farming and managing village workshops for agricultural machinery. They produced controlled sensors for smart greenhouses, closed-house systems for chickens, and food processing machinery.

AE/ABE inventors have founded their own companies, or started from a small one and grown bigger. Some received a patent for their invention. They successfully transform their inventions into innovations. Dr Anang Lastriyanto from ABE Study Programme, Brawijaya University, Malang, East Java, is among them; his profile is presented in Box 19.3. The multiplier effect of his invention, the vacuum frying machine, could be illustrated as follows. Take for an assumption that 1600 out of over 2000 machines he manufactured (Box 19.3) were sold to small and medium-scale food industries. The industries used the machines for the production of any kind of fruit chips and fish-dried chips. If it says each industry would hire 5–10 employees, the impact of the innovative machines improved the living quality of 8,000–16,000 people, not counting the employees in the machinery manufacturing plant, the farmers and fishermen who supplied the raw materials for the food industries, the packaging industries, and the distribution chains. Further, the food chips produced by the vacuum frying machine have lower oil content than the deep-fried chips. This, too, contributes to the healthier food product for the consumer.

BOX 19.3: DR ANANG LASTRIYANTO

An Agricultural Engineering faculty staff member who has been successful in developing a manufacturing company for food processing machinery, Dr. Anang Lastriyanto is an innovator of vacuum frying machines.

He designed, tested, and modified his invention as early as in the year 1995. He later established a small workshop that manufactured his machines and sold them to food industries making fruit chips. He claimed that the machine will reduce the oil content in the chip products as much as 15–20% compared to deep frying oil products.

He kept doing research and development to improve his machines. As the results, vacuum fried products in the market not only covered a broad spectrum of fruit and root crop varieties but also fish-dried chips and meat products. He generously served buyers with several days training at his places for free. He further built a simple boarding house for the operators who needed cheap accommodation during the training.

By 2022, over 2000 units of his machines at different capacities have been sold to small and medium-scale food industries, and also to education institutions around Indonesia. He patented his invention under the Patent Right No. ID P0026372B. In the last years, he founded a legal company to ensure the sustainability of his enterprise, now turned to a bigger plant. His new machine ready for commercialisation is an integrated honey processing with pasteurisation, evaporation, vacuum cooling and filling, thus keeping the original quality of honey.

With all his career in business, he is a dedicated faculty staff at AE/ABE Study Programme, Brawijaya University, Malang, East Java. He pursued his MSc degree at IPB University, and his PhD at the Faculty of Engineering at his home university.

An AE faculty staff member plays a key role in the foundation and management of a business incubator in the university and its development towards the Science Techno Park, as marked by the development of the business incubator at IPB University, Bogor, West Java. The business incubator of IPB University is among the first four business incubators established in Indonesia in 1994. Later, the same AE faculty staff member also contributed significantly to the national programme to build and strengthen business incubators around Indonesia. To this day, over 180 business incubators are claimed as members by the AIBI – Association of Indonesian Business Incubators (AIBI, 2022), not to mention many business incubators that are not members of the association, such as for-profit incubators owned by conglomerate companies.

With this brief observation, it could be concluded that agricultural engineers/agricultural and biosystems engineers in Indonesia have participated in national economic development and left their signatures in the community welfare and education, which has undoubtedly improved in the last decades.

Agricultural engineers/ agricultural and biosystems engineers in Indonesia have also contributed to the world. Some became principal investigators in research in other countries, like Dr Nanik Purwanti, faculty staff at the ABE Study

Programme, IPB University, Bogor, West Java in Ireland in 2019–2021 (Box 19.4). Others actively published their scientific articles in Q1-level Scopus scientific journals, like Prof. Dr Budi Indra Setiawan, faculty staff at the Civil, and Environmental Engineering faculty, IPB University, Bogor, West Java (Box 19.5). They might be invited as a visiting scholar (Box 19.5), as editors in the proceedings of international conferences or seminars (Purwadaria et al. 2002, and Purwadaria et al. 2013), and as writers of chapters in books together with worldwide recognised experts (Purwadaria et al. 2006, Purwadaria et al. 2016, Zhang et al. 2020a, and Zhang et al. 2020b). Many lead research and development projects in Indonesia, cooperating with regional and international institutions.

BOX 19.4: DR NANIK PURWANTI

A woman agricultural engineer who has a reputation for getting international research funding, Dr. Nanik Purwanti was a singular principal investigator of Increasing Processability and Overall Valorisation of Irish Acid Whey in Teagasc Food Research Centre, Moorepark, Ireland for three years in 2019–2021. The research aimed to characterise the effect of seasonal and processing variation on acid whey stream from casein manufacture. This research explored the effects of pretreatments of acid whey on the manufacture of whey protein concentrate and permeate powders. The research was in close collaboration with Arrabawn Co-operative Ltd Ireland, a major manufacturer of acid whey powder with interest in increasing volumes of acid whey products. The research was co-funded by the European Union, under the Horizon 2020 Marie Skłodowska-Curie Actions in partnership with Enterprise Ireland.

Her work was recognised by L'Oreal-UNESCO for Women in Science (FWIS) National Fellowship Programme in 2014, from which she was granted a research award about Whey Protein Stabilised Emulsion for Microcapsules Materials in 2014–2018. She extended the research by exploring soy protein isolates (SPI) from Indonesian soybean varieties and SPI fibrils to replace the functionality of whey protein for microencapsulation. She was also nominated by the L'Oreal–UNESCO FWIS National Fellowship to represent Indonesia in the International Rising Talents Programme 2015.

Nanik has published over 30 scientific articles in several international and national journals. She is a dedicated faculty staff member at the ABE Study Programme, IPB University, Bogor, West Java where she graduated as Bachelor of AE. She obtained her MSc and PhD degrees at Wageningen University & Research, the Netherlands, in the years 2007 and 2012, respectively.

BOX 19.5: PROF BUDI INDRA SETIAWAN

An agricultural engineering alumnus who is most active in scientific publications, Prof Budi Indra Setiawan also published more than 50 other articles in other scientific journals both international and domestic at the same five years. Not to count his articles in Proceedings. He is the author of a book chapter in *Supply Chain Resilience: Reducing Vulnerability to Economic Shocks, Financial Crises, and Natural Disasters*, published by ERIA-Springer in 2020.

His researches covered cooperation both with national and international institutions, and linked to national corporate industries as well. He has made significant contributions to national policy in land and water management. In 2014–2019 he was nominated as a member of the Ministerial Expert Team working for the Minister of Agriculture, Republic of Indonesia.

Gaining international reputation, he has been invited as visiting scholars to several international universities and institutions prior to these last five years. He has been serving as one of the editors of the PAWEE – Paddy and Water Environment Engineering Journal since 2003, and eventually received the International Award from PAWEE in 2010. He served as a member of Technical Section 1: Land and Water Engineering, CIGR since 2007.

He was a dedicated faculty staff member at the AE Study Programme previous to moving, in 2010, into the Civil and Environmental Engineering Study Programme that he helped found at IPB University, Bogor, West Java.

Budi Indra obtained his AE bachelor degree at IPB University, then pursued his MSc and PhD at the University of Tokyo in Japan. He achieved his full professor in the field of Soil Physics and Hydrology in 2004.

Shaping for the Future

Entrepreneurship Programme as an Alternative to Research in the Final Project

Looking at the interests of the undergraduate students with the creation of startups that conforms to the growing interests of Gen Y, it will be most appropriate if the AE/ABE curriculum fully integrates the entrepreneurship courses and practices into the Final Project. Many startups founded by AE/ABE alumni reached success in their businesses. For example, the following two startups have already grown into legal companies. One is from Gadjah Mada University producing an IoT farming solution platform combined with IoT multi-sensor equipment

for oil palm plantations (*PT Merapi Tani Instrument,* 2022), and another one is from IPB University producing Agritech Data Processing 4.0 and sensor technology equipment for the smart farming system, for either indoor or outdoor farming (Box 19.6).

BOX 19.6: BUNG DAKA PUTERA

A biosystem engineering graduate, Bung Daka Putera built his startup while he was still in his junior year in 2019. His idea became both the 1st Winner of Indonesian Acceleration for students' startups, and the 1st Winner of Agri-Maritim technology in 2019.

Eventually, right after his graduation from ABE-IPB University in 2020, he and some of his friends built their company PT Kharisma Agri Inovasi, manufacturing agritech data processing 4.0 and sensor technology equipment for smart farming system either indoor or outdoor farming.

In 2021, the startup was successful in getting a seed money grant from the Ministry of Research and Technology/BRIN (National Agency for Research and Innovation). In the same year the startup was listed as among the Best 15 in the ASEAN Startup Challenge.

So far, the company has been successful in selling over 175 units of monitoring and controlling devices for 48 + greenhouses and a 156 ha ginger farm.

His enterprise can be found at http://kharismacrop.com

It will only be fair that the education system prepares and supports the interests of undergraduate students and their expectations for their careers after graduation. Rather than a top-down initiative taken by the Ministry of Education, Culture, and Research Technology at Channel 6 of Independent Learning-Independent Campus with a total of 20 SKS entrepreneurship programmes as discussed in Sub-Chapter 1.4., it would be more sustainable if the universities take the initiative in a bottom-up way with the education system substituting the entrepreneurship programme for the 6 SKS of a research manuscript.

At many universities in Indonesia, the entrepreneurship skill of the graduates is strengthened not only by the curriculum but also by the institutions called business incubators. Fifteen out of 17 universities offering AE/ABE Study Programmes have a business incubator at the university level (AIBI, 2022). Two business incubators have developed into Science Techno Parks, one focusing on agribusiness and agroindustry at IPB University Science Techno Park at Bogor, West Java, and the other on the biomedical industry at Gadjah Mada University Science Techno Park at Yogyakarta, DIY. It is also interesting to note that the founder of the business incubator at IPB University in 1994 is an AE faculty staff member, as well as the current director of the IPB Science Techno Park, while the manager of the Gadjah Mada University business incubator is an AE alumnus. Using the business incubators' services, the entrepreneurship programme, as an alternative for research in the Final Project, will ensure more diversions for the graduate career. One of the successful startups incubated by a business incubator has been illustrated in Box 19.6, an incubatee in the IPB business incubator.

Towards Secure Food Availability, Human Wellness and a Better Environment

Summarising the evolution of Agricultural Mechanization education into AE/ABE in Indonesia and visualising the future, a roadmap for AE/ABE education could be structured as illustrated in Figure 19.2. Since the transformation of Agricultural Mechanization into AE/ABE has been narrated, the following describes the last part of the roadmap which is the AE/ABE education beyond 2023.

Nowadays, AE/ABE scientists and students discuss climate change because of greenhouse gas emissions, sustainable agriculture, food security, precision farming, and Industry 4.0. They are researching in these areas, making presentations in scientific seminars and conferences, and publishing articles in scientific journals. However, looking at the curricula in Tables 19.3 and 19.4, few courses support the mission to implement sustainable agriculture and food security through precision farming and Industry 4.0. There are some, like Robotics Engineering in the ABE curricula of IPB University; Smart Farming, and Remote Sensing in the ABE curricula of Udayana University. In other universities like Jember University, there are GIS, IoT, Machine Learning and Deep Learning, and Precision Agriculture courses.

Some additional core courses in emerging technology that could be considered to achieve the necessary needs for the ABE undergraduate curriculum are Plant Factory/Inside-Door Farming, Smart Greenhouse/Smart Farming, Mobile Application Based Control/Bio-Sensing/Bio-Process Control, Image Processing, Non-Destructive Quality Evaluation of Agricultural Products, and Mitigation for Climate Change in Farming.

People in the world, as well as in Indonesia, are facing an alarming increase in the human population, and thus an increasing demand for food supply. There is also a trend of acute interest in human health and wellness. Meanwhile, in activities to satisfy the necessary foods and wellness, people create environmental problems, such as deforestation and production of gas emissions, causing the build-up greenhouse effect, climate change, and natural disasters. A sustainable agricultural system must be developed by the intensive multidisciplinary approach of ABE with other fields such as agronomy, food technology, mechanical and electrical engineering, and biomedical engineering. In finding a solution to minimise the impact of climate change, the agricultural system will best integrate local wisdom traditionally proven successful into emerging technology.

So far, plant factory is applied to common vegetables that could be sold at high prices. In the future, other tropical vegetables and herbs must be grown in the same system at a reduced cost.

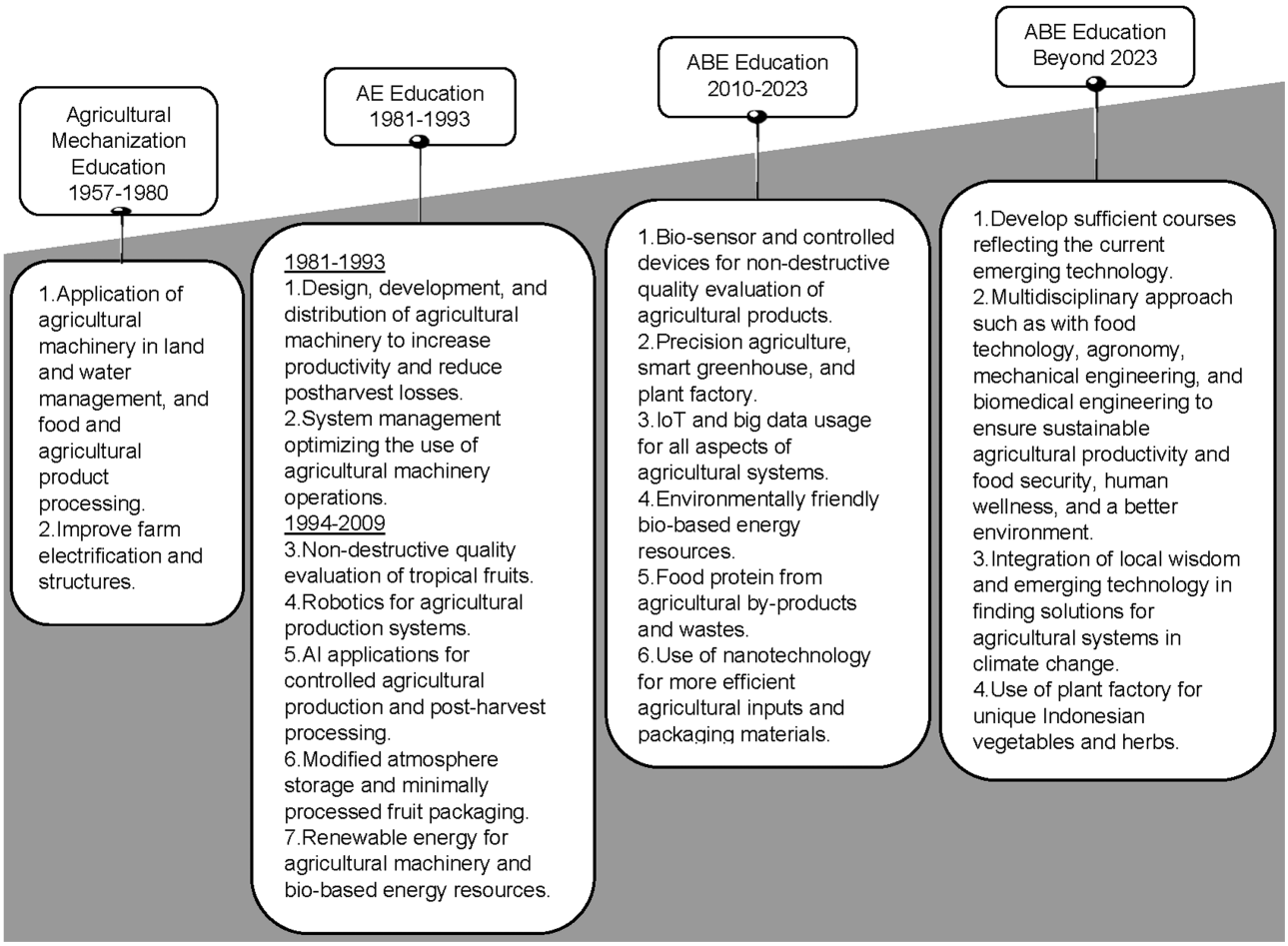

FIGURE 19.2 Roadmap of Agricultural Engineering/Agricultural Biosystems Engineering (AE/ABE) education in Indonesia.

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