PAPER NO. 85-5043

THE EDUCATION AND UTILIZATION OF AGRICULTURAL ENGINEERS IN THE DEVELOPMENT OF INDONESIA

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For Presentation at the 1985 Summer Meeting
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Michigan State University, East Lansing
June 23 - 26, 1985

SUMMARY:

The role of AE graduates in Indonesia will increase in line with national programs on food, alternate energy, waste product utilization, soil conservation, industrial pollution control, computer application and biotechnology.

THE EDUCATION AND UTILIZATION OF AGRICULTURAL ENGINEERS IN THE DEVELOPMENT OF INDONESIA [1]

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BACKGROUND

Modern agriculture in the developing countries requires dynamic farmers who can quickly interpret the developmental technology and the demand for agrocommodities. Undoubtedly, investment in information and knowledge is a fundamental source of productivity growth and social welfare. Education speed up the process of technological diffusion, especially in the case of agriculture. In this context, strong linkage can be observed between education and utilization of agricultural engineers. This linkage is detected by the increasing role of agricultural engineering in the development of Indonesia.

Despite encouraging progress in petroleum export and industrial activity, the mainstay of Indonesia economy in the foreseeable future will be agricultural sector. Thirty percents of the Gross Domestic Product and one thids of the export earnings are derived from agriculture. It is estimated that agriculture employs over 60 percents of the urban households. In order to achieve the projected economic growth rate of 6.5 percent per year, agricultural production is required to increase at 3.5 percent annual rate.

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[1] Prepared for presentation at the ASAE Summer meeting, June 1985

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To meet the projected consumption requirements of 150 million population, with a rapid growth of 2.3 percent per year and stimulated by rising agregrate income, it is estimated that food production must be doubled in just 17 years. Furthermore, in lime to get more foreing currency earnings, industrial crops, fishery and forestry production should generate sufficient additions to non oil export revenue. These are basic challenges faced by agricultural engineers now and in the years to come.

RECENT DEVELOPMENT OF AGRICULTURAL TECHNOLOGY

The agriculture in Indonesia is diverse. However, within the diversity there are several characteristics which are generally typical for smallholders activity across the islands.

(1) holdings are generally small

3.00 ha	:	5.6 percent
0.75 - 3.00 ha	:	32.9 percent
0.30 - 0.75 ha	:	32.9 percent
0.30 ha	:	28.6 percent

(2) most farm activity is devoted to food crops production (86.6 %) and only about 12 percent have mixed crop/livestock or poultry production.

(3) the area of irrigated farming is 34.2 % of total crop acreage. Little of this irrigation is classified as technical (13.56 %) and semi-technical (13.74 %).

(4) there is relatively low use of fertilizer and pesticides. Only 37.8 % apply chemical fertilizer, 12.6 % farm manure and 6.8 % combination of both. The average amount of chemical fertilizer applied is 170 kg/ha.

(5) most of the power supplied by manual labor, eventhough the land cultivation cost with a tractor is 60 US $/ha compare with 70 US $/ha for manual labor.

(6) only around 30 % of farmers live in moderate condition. Most of them have weak purchasing power for industrial goods. Each harvest of rice the average net income is just about 200 US $/ha.

Considering those conditions the technological improvement introduced by agricultural engineers has had difficulties and lots of failures have occured in mechanized projects. However to some extent, the advance of agricultural technology has improved significantly, particularly in post harvest activities and irrigation pumps. Table 1 shows the current and projected need for agricultural implements and machineries.

Table 1. Agricultural Equipments and Machineries in Indonesia *)

Specification	1984	1985	1986	1987	1988
Tractor	19200	23040	27640	33200	39840
Sprayer	63000	72000	83300	95800	110280
Irrigation Pump	3300	4290	5380	6270	7260
Rice Thresher	36600	38100	39500	40920	42350
Grain Winnower	1916	4035	4318	6739	5073
Rice Milling Unit	6600	5888	6100	6300	6250
Grain Dryer	5500	5720	5940	8160	6380
Rice Transplanter	127	332	449	770	1380
Reaper	1290	2077	2780	4179	5546

*) Department of Agriculture, GOI , 1984

The implementation of agricultural technology is relevant to the national strategy of agricultural development These are :

(1) <u>intensification</u>, an increase of productivity through utilization of appropriate technology which still considers the conservation of energy, natural resources and the environment.

(2) <u>extensification</u>, which includes the expansion of new agriculture areas by using arable land related to the new settlement and transmigration efforts.

(3) <u>diversification</u>, a variety of farming system to produce various commodities in line with local resource potential and market demand.

To support the technological adaption and transfer on these programs, agro-based industry must also improved. The main industries are product processing plants, and equipment and machineries manufacturing plants. Table 2 shows the production capacity of agricultural equipment manufacturing industries in 1984.

Table 2. Production Capacity of Agricultural Equipment Manufacturing Industry in Indonesia, 1984 *)

Specification	Production Capacity per Year			Total
	Licensed	Potential	Actual	Company
Hand hoes	1 072 000	950 060	530 036	4
Hand Tractor	27 660	6 088	2 361	13
Mini-tractor (4-wheel)	3 100	1 700	50	3
Water pump centrigugal	14 025	15 275	400	3
Water pump axial	2 400	2 350	2 115	1
Sprayer	146 750	69 900	50 250	7
Duster	19 500	17 000	4 000	3
Pedal Thresher	1 000	1 000	-	1
Power Thresher	3 550	1 050	244	6
Paddy Separator	150	100	50	1
Dryer	1 160	803	287	5
Rice Polisher	2 350	1 400	300	3
Rubber roll	300 000	24 000	12 000	1
Huller	3 700	3 375	-	3
Rice Mill Unit	1 800	-	-	2
Corn Sheller	5 030	3 000	2 025	2

*) Association of AEM - Manufacturers (ALSINTANI), 1984

EDUCATION OF AGRICULTURAL ENGINEER

Higher learning institutions of agricultural engineer in Indonesia were started formally in 1963 at the Faculty of Agricultural Technology, University og Gajah Mada (UGM). In 1964, a similar faculty was formed in the Bogor Agriculture University (IPB). Before then, agricultural mechanization was only part of the crop science curricullum in the Faculty of Agriculture. Through a US-AID program, a Kentucky University consultant had been retained to accelerate the AE education program in both universities. Members of the teaching staff were trained in US. In the beginning of 1970, the MUCIA - AID program begun and contributed much to the AE Department of IPB and UGM. Long term and short term experts were assigned to develop appropiate curriculum. The contribution of Prof. Stout and Prof. Esmay has been recognized by both universities. The concept of selective mechanization was introduced and has expanded.

The growth of AE department quantity and quality wise, begun to accelerate faster as several staff members came back from US with advanced degrees. Other universities have also started AE curriculums. These include the University of Hasanuddin in South-Sulawesi, the University of Andalas in West Sumatra and the University of Brawijaya in Malang. IPB and UGM have produced graduates since 1970, and at present there are about 700 agricultural engineers. This amount is far from enough for the agricultural technology manpower requirement in Indonesia. The student body in the AE department in IPB is around 300 and in UGM it is around 250.

In the early years the AE curriculum at IPB had been estimated to have only 35 percent engineering courses, but today there are around 86 percent that are considered as engineering science. (see App. 1 for the recent curriculum)

The specialization fields covered by AE Department are:

(1) Farm machinery and equipment
(2) Soil and water engineering
(3) Agricultural hydrology and irrigation
(4) System and management for agricultural mechanization
(5) Food and agricultural products processing
(6) Energy and rural electrification
(7) Environment and farm structure

In 1981, the Faculty of Agricultural Technology at IPB founded a new department in order to provide professionals needed for the fast growth of the agro-industry in Indonesia. At present, the Department of Agro-Industrial Technology (AIT) has already produced more than 40 graduates working in various field of the agro-based industry. (see App. 2 for AIT curriculum). This department covered 3 main specializations:

(1) industrial engineering and management
(2) agro-chemical engineering
(3) bio-technology/bio-industry

The AIT Department also has a quality control and packaging laboratory. During 1984, UGM began to set up a similar department.

The demand for the AIT graduates is increasing. Mostly this comes from the estate crops processing industry. Computer application has been the main thrust in the AIT department. It is extensively used for management science and operation research courses. Software technology has begun to be appreciated in agriculture bussiness.

Graduate study for AE was started at IPB in early 1980, both in Master and Doctor program. The curriculum of AE graduate programs is attached in Appendix 3. With aid from Japan International Cooperation Agency (JICA), the graduate program at the Faculty of Agricultural Technology is growing fast. A new building has been erected and technical assistance for a 3 years program has been planned. The in-country graduate program will enable Indonesia students to select their research or dissertation studies relevant to the current problem in agricultural technology.

UTILIZATION OF AGRICULTURAL ENGINEER

The number of Indonesian researcher and scientist involve in agriculture problem are relatively small. In 1975 there were only 900 researchers to fill a total need of 18,500 for the same year. This shortage should be solved immediately to prepare the even more challenging problem on food, energy, environment and population explosion issues. To cope with human resources development, the state universities of Indonesia has been stressed to increase their student body by to 10 to 15 percents per year. Budged constrainsts make this effort very difficult to achieve.

To gain an overall view of the utilization of AE graduates is not easy since there is no fixed record of their employment. Table 3 shows the AE alumni of IPB to the year of 1979, concerning their occupation distribution.

This table shows that about 21 percent at the graduates are working in University and around 22.5 percent work in the private sector. More than 65 percent work in various governmental agencies. It is expected that the private sector will utilize more in the future. The small sumbers that work in the private sector in due to limited growth of mechanization for small farming system and current slow investment in agro-business. Most of them work as sales engineers for big international companies, but very few works in local manufacturing industry or private mechanization projects.

In 1967, the first symposium of Agricultural Mechanization was held in Bogor. On August 10, 1968 the Indonesian Society for Agricultural Engineer (PERMETA) was established. This professional organization has conducted several seminars, technical meeting and conference to discuss the national issues in agricultural technology application. Its members include scientists, university staff, factory managers, field practioners, research workers, government representatives and students.

Tabel 3. AE Alumni of IPB, Occupation Distribution

Year	Higher Learning Institute	Research Bodies	Government Agencies	Government Owned Company	Private Sector	Other *)
1970	0	2	0	0	0	0
1971	2	2	0	0	0	0
1972	1	0	0	0	1	0
1973	3	0	1	0	1	0
1974	4	3	3	3	5	0
1975	6	5	3	3	2	2
1976	2	3	1	6	1	1
1977	3	1	2	6	4	1
1978	3	1	5	3	0	1
1979	2	2	5	0	7	2
Total	26	19	20	21	21	7

*) Bank, Cooperatives, Consultants etc.

FUTURE TRENDS

In the Indonesia National development strategy, it is stated that higher learning institution should increase their role as the center for science and technology development as well as the center for developmental research related to national goals. Therefore, they should improve their productivity, creativity, quality and work efficiency. In this decade, most agro-complex universities in Indonesian are in the phase of improvement to their physical facilities and human resources. There is a great deal of international aid involved in this program. Since they are still in the process of institutional building, their production evaluated as still inadequate to meet the national demand of alumni and technological progress.

In the field of Agricultural Technology, there are several factors that could accelerate the growth of the AE profession. These factors can be identified as :

(1) Food Availability. Intensification of farm land is not enough to supply food adequately since the yield per hectare is reaching its optimal value. Therefore, extensification which requires the use of heavy machineries is intended to supplement the production efforts.

(2) Alternative Energy. Fuel in rural areas is expensive and not feasible for various commodities processing factories. Green energy, such as gasohol from cassava starch, is increasing as well as wind, water and solar energy for farming usaged. However, further research still has to be done to improve the efficiency.

(3) Waste Product Utilization. More than 70 % by weight of agricultural plants are wasted. The new process of waste utilization could add to farmers income considerably, i. e. paddy stalk, cocconut shell, sugar cane tops etc.

(4) Soil Conservation. The environmental is a big issue nowadays for marginal land. Erosion control through better drainage and land development pattern is needed in many parts of the country.

(5) Industrial pollution Control. Some of the agro-process industry produce pollutant, such as cassava starch factories. There should be technological efforts to reduce the negative impact to the living environment especially in the rural areas.

(6) Computer Application. Management is one of the weakest part of the agro-business, from traditional farming to large scale estate crop plantations. Computer application combined with software technology could assist in developing management information and decision support systems. It will increase planning and evaluation efficiency and effectiveness in governmental agencies and private industries.

(7) Bio-technology. The use of micro-organism in producing foodstuff has been known since quite long ago (i. e. tempeh, soy bean sauce etc.). The advancement of bio-technology is a future challenges that can provide new horizon for agricultural engineers.

In spite of many accelerated factors, the AE educational system still is confronted with difficulties in its professional development. The lack of educational facilities, especially in hardware training, produce not-so-ready graduates. Beside, the agro socio-economic condition in Indonesia, where smallholders is dominant, makes technological innovation and dissemination quite difficult. But there is no doubt that AE graduates role in national development will be expected to increase. International cooperation on research and development is necesarry to support this development with aim to building a better world.

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APPENDIX 1

Agricultural Engineering Undergraduate Curriculum *)
Bogor Agriculture University

1-st Semester		2-nd Semester	
FIS 101	Physics (3)	STK 102	Mathematics II (3)
FSM 101	Indonesian Language (2)	BOT 102	Biology (3)
		FSM 116	Chemistry II (3)
FSM 102	English (3)	SEP 101	Intro to Ekonomic (3)
STK 101	Mathematics I (3)		
FSM 115	Chemistry I (3)	FSM 202	Physical Science (2)
FSM 206	Introduction to Agricultural Sciences (1)	SEP 121	Rural Sociology (3)
		FSM 100	Religion (2)
FSM 117	National Philosophy/ Pancasila (2)		

3-rd Semester		4-th Semester	
STK 201	Calculus I (3)	TEP 202	Engineering Mathematic (3)
TEP 211	Intro to Agricultural Engineering (2)	STK 211	Statistical Method (3)
TEP 201	Static and Dynamics (3)	TEP 231	Surveying (2)
TEP 202	Fluid Mechanics (3)	TEP 214	Engineering Workshop (3)
TEP 212	Engineering Drawing (3)	TEP 271	Construction Materials (2)
AGM 211	Basic Climatology (3)		
TEP 213	Computer Application (3)		

*) - Code TEP is for courses offered by AE department
- Total credit-hours 144 - 145

5-th Semester		6-th Semester	
TEP 311	Strength of Material (3)	TEP 322	Engineering Mechanics (3)
TEP 321	Farm gas Enginer and Tractors (3)	TEP 341	Engineering Economy (3)
TEP 331	Hydrology (3)	TEP 342	Intro to System Analysis (3)
TEP 361	Energy and Agricultural Electrification (3)	TEP 362	Environmental Engineering (3)
Group A only *)		Group A only	
TNK 211	Intro to Soil Science (3)	TEP 332	Soil-Water-Plant Relation ship (3)
AGR 211	Basic Agronomy (4)	TEP 323	Farm Equipment and Machineries (3)
Group B only **)		TEP 333	Soil and Water Engineering(3)
ITP 301	Intro to Food Technology (2)		
TIN 311	Plant lay-out and design (3)	Group B only	
		TEP 351	Food Engineering (4)
		TEP 352	Agric. Product Proces Engineering (3)
		TEP 371	Farm Structure and Construction (3)

7-th Semester		8-th Semester	
TEP 411	Engineering Analysis (3)	KKN 399	Field Practices (6)
	- Electives (12)	TEP 497	Field Study in AE(3)
		TEP 498	Seminar (1)
		TEP 499	Special Problem (6)

*) group A : Specialization on farm power and machinery, or Soil and water engineering

**) group B : Specialization on product processing, farm engineering, farm energy and electrification, farm structures

ELECTIVES

TEP 421 Ergonomics (3)
TEP 422 Soil and Farm Equipment Relationship (3)
TEP 423 Land clearing and development (3)
TEP 424 Farm Equipment and Machineries design (3)
TEP 431 Waktu Resorce development Engineering (3)
TEP 432 Irrigation and Drainage (3)
TEP 442 Management for form labor and Form Machinery (3)
TEP 451 System Analysis for Form Industry (3)
TEP 452 Post-Harvest Engineering (3)
TEP 453 Referigeration Engineering (3)
TEP 461 Energy (3)
TEP 462 Automatic Control (3)
TEP 463 Rural Electrification (3)
TEP 471 Farm Structural Design (3)
TEP 301 Applied Mathematics (3)

APPENDIX 2

Agro-Industrial Technology Undergraduate Curriculum
Bogor Agricultural University

1-st Semester		2-nd Semester	
FIS 101	Physics	STK 102	Mathematics II (3)
FSM 101	Indonesian Language (2)	BOT 102	Biology (3)
FSM 102	English (3)	FSM 116	Chemistry II (3)
STK 101	Mathematics I (3)	SEP 101	Intro to Economic (3)
FSM 115	Chemistry I (3)	FSM 202	Physical Science (2)
FSM 206	Intro to Agricultural Sciences (1)	SEP 121	Rural Sociology (3)
FSM 117	National Philosophy/ Pancasila (2)	FSM 100	Religion (2)

3-rd Semester		4-th Semester	
STK 201	Calculus I (3)	FIS 102	Applied Physics (3)
TIN 201	Intro to Industry (2)	STK 221	Statistical Methods (3)
TIN 212	Industrial Equipment and Machinery (3)	TEP 207	Computer Application (3)
TIN 221	Physical Chemistry (3)	TIN 221	Time and Motion Study (2)
TIN 222	Intro to Chemical Engineering (3)	TIN 224	Unit Operation (3)
TIN 223	Industrial Material (3)	TIN 202	Personal Management (2)

*) - Code TIN is for courses offered by AIT Department
- Total credit-hiurs : 144

5-th Semester		6-th Semester	
TIN 302	Industrial Equipment (3)	TIN 301	Industrial Sociology (2)
TEP 301	Strength of Materials (3)	TIN 312	Operation Research I (3)
TIN 321	Unit Process	TIN 314	Project Planning (2)
TIN 344	Industrial Instrumentation (3)	TIN 342	Industrial Saritation Engineering (3)
TIN 313	Plant lay-out and Design (3)	TIN 343	Labour and Safety (2)
TIN 341	Principles of Quality Control (3)		- Electives (9)
	- Electives (3)		

7-th Semester		8-th Semester	
TIN 401	Enterpreneurship (2)	KKN 399	Field Practice (6)
TEP 401	Engineering Economics (3)	TIN 497	Job Training (3)
		TIN 498	Seminar (1)
TIN 403	Industrial Planning (2)	TIN 499	Special Problem (6)
SEP 341	Industrial Economic (3)		
	- Electives (9)		

ELECTIVES

A) Industrial Engineering and Management Group

TIN 345 Production and Process Control (1)
TIN 412 Operation Research II (3)
SEP 353 Agro-business Management (3)
TIN 411 Optimization Technique (3)
TEP 402 Engineering Analysis (3)
TEP 202 Engineering Mathematics (3)
TIN 442 Statistic for Quality Control (3)
SEP 362 Agricultural Marketing (3)

B) Agro-Chemical Technology Group

TIN 322 Wood and Fiber Technology (3)
TIN 323 Fat and Oil Technology (3)
TIN 324 Aromatic Technology (3)
TIN 325 Starch and Sugar Technology (3)
TIN 327 Agro-Pharmacy Technology (3)
TIN 328 Essence Oil and Cosmetics Technology (3)
TIN 325 Leather Technology (3)
TIN 333 Polimer Technology (3)
TIN 331 Packaging (3)

C) Bio-Industry Group

TIN 351 Industrial Microbiology (3)
TIN 346 Storage and Warehousing (3)
TIN 212 Bio-chemistry (3)
ITP 321 Food Microbiology (2)
ITP 421 Fermentation Technology (3)
ITP 451 Industrial Waste Processing Technology (3)

APPENDIX 3

Graduate Program in Agricultural Engineering
Bogor Agriculture University

A. Master Program (34 - 36 credit hours)

At present their are three field of in terest in AE graduate program :

(a) Farm Power and Machinery
(b) Processing Engineering
(c) Soil and Water Engineering

1-st Semester		2-nd Semester	
TEP 501	Applied Mathematics 93)	AGR 590	Research Methodology (3)
STK 511	Statistics (3)	TEP 520	Adv. Farm Machinery (3) -A
TEP 504	Instrumentation (3)	TEP 540	Product Processing Engineering (3) -B
	- Elective (3)	TNH 542	Soil Physics (3) - C
			- Elective (3 - 6)

3-rd Semester		4-th Semester	
TEP 601	Colloqium (1)	TEP 690	Seminar (1)
TEP 620	Farm Power and Alternative Energy (3) -A	TEP 699	Research (6)
TEP 640	Food Processing Engineering (3)-B		
TEP 660	Irrigation Engineering (3) -C		
	- Elective (3 - 6)		

B. <u>Doctor Program</u> (48 - 53 credit hours, after Master degree)
Arranged by the Guidance Committee

<u>Electives for Master an Doctor program</u>

TEP 502	Agro-Industrial Engineering (3)
TEP 503	Transport Phenomena I (2)
TEP 530	Strategy in Agricultural Mechanization (3)
TEP 531	Soil-Machinery Relationship (3)
TEP 532	Engineering Mechanics (3)
TEP 550	Advance Thermodynamics (3)
TEP 551	Advance Heat Transfer (3)
TEP 570	Water-flow measurements (3)
TEP 571	Erosion and Control Structures (3)
TEP 572	Engineering Hydrology (3)
TEP 603	Transport Phenomena II (2)
TEP 610	Applied Engineering (3)
TEP 611	System Analysis (3)
TEP 612	Numerical Analysis (3)
TEP 630	Ergonometrics and Safety (3)
TEP 631	Tractor Testing and design (3)
TEP 650	Post-harvest Technology (3)
TEP 662	Drainage Engineering (3)
TEP 670	Open Channel Hydroulis (3)
TEP 730	Solar Energy Conversion Technology (3)
TEP 750	Thermal System Design (3)
TEP 751	Thermo-Physical Characteristics of Agric. Products (3)
TEP 760	Groundwater Hydroulics (3)
TEP 770	Hydrologic Modeling-small Waterched (3)
TEP 772	Water Resouses System Design (3)