Present status and outlook of coconut development in Indonesia

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Abstract. Coconut (Cocos nucifera L.) is a socioeconomically important palm in Indonesia, owned mostly by smallholders. Indonesia has the largest coconut palm-growing areas in the world, followed by the Philippines and India. The average national coconut productivity is still lower than the production potency of superior varieties. Indonesia and the Philippines contributed about 67% of crude coconut oil (CNO) export to global market. At present, the global market demand of coconut oil is fluctuating lead to the low price of CNO, while demand for certain coconut products such as coconut water, milk and flour is growing rapidly. This review provides an overview of the present status of coconut development in Indonesia, the recent advances in technologies for coconut improvement and outlook of coconut development toward 2045. Technological, political and socio economic issues including senility, pests and diseases, inferior varieties, poor agronomic practices, land conversion affected the low coconut production, while unfavorable supply chain, narrow product line, low product quality, monoculture-planting system might be affected the economic welfare of farmers. About 6.6 million farmers rely their main source of income on coconut and coconut based-products, which are mostly copra and CNO. Technological and institutional innovations for smallholder in coconut development become important strategies. Producing high value coconut products, establishment of seed farms, replanting of senile palms, pest and disease management, synergy among industries, farmers, and governments as well as research on finding more innovative technologies and technology transfer to solve existing problems are required to ensure the sustainability of coconut sector.

Key words: coconut, coconut-based products, farmers

1. Introduction
Coconut (Cocos nucifera L.) plays an important role in the economic, social and cultural life of many people in Indonesia. It has geographically spread and been cultivated in almost every province of Indonesia. Riau, North Sulawesi and East Java are the first, second and the third largest coconut producing provinces, respectively. It is a major source of income for ca. 6.3 million farmers [1] Every part of the palm is useful and becomes source of healthy foods and beverages, houses, furniture, handicrafts, and bioenergy. Various traditional foods in Indonesia use coconut as key ingredient. As one of ingredient in our dishes, coconut has significant roles in our daily life and contributes to the livelihood of farmers since coconut plantation is belonging to 98% of smallholders. Coconut shell is processed into Coconut Coir, Coir Yarn, Coco peat, and mat. Coconut water is processed into Coconut Drink, Nata de Coco, Coconut Vinegar, and Coconut Sauce. From coconut meat a number of products are traded such as Coconut Flour, Coconut Milk, Coconut Butter, Virgin Coconut Oil, Copra, and Young Coconut. In addition to being processed into food, Indonesia also develop processed coconut products into doormats and car seat fillers.
Coconut production in 2018 was estimated 2.9 million tonnes from 2.6 million ha of mature palms, with productivity ca. 1.1 tonne/ha/year [1]. The present productivity is still far from the production potency of superior varieties, which can reach more than 2.8 tons/ha/year. Pests and diseases inferior varieties as well as out-dated agronomical practices, land conversion, and the high proportion of senile palms in the field are all contributing to this present low productivity. Major pests and diseases attacking coconut plants, including coconut rhinoceros beetle (*Oryctes rhinoceros* L.) [2] [3], coconut leaf beetle (*Plesispa reichei* (Chapuis, 1875)), coconut hispid beetle (*Brontispa longissima* Gestro) [4] [5] [6], and coconut bud rot disease (*Phytophthora* spp.) and nut fall disease (*Fusarium* and *Phytophthora* spp.) [7] [8] [9]. Issues of inconsistent and low supply of raw materials to industries, monoculture planting system, inefficient supply chain, price fluctuation and narrow products diversification, low quality of products as well as non-utilization of by-products of coconut are factors contributing to the low income of farmers and minimal profit obtained by industries.

Coconut is contributing to national income since its export reached more than USD 1.3 billion or equal to 2.17 million tonnes in 2018 [1]. However, Indonesia has less variety of coconut export products and its foreign exchange revenue than that from India and Philippines. The top three export products in 2018 are coconut oil, followed by crude coconut oil-copra, and desiccated coconut. Types of coconut products traded significantly determine on-farm income at the village level. The demand for various coconut products as functional foods and drinks in the nonproducing countries has significantly increased [10]. Indonesia through The Ministry of Agriculture set a program to increase coconut production, promote product manufacture, create a conducive business environment, and boost exports of high value added coconut products for increasing export revenues and improve farmer’s income. Programs to improve crop production involve research and development program to produce superior varieties, seed development (local government, self-seed production villages, and promote seed business), expansion of plantations and revitalisation of coconut in urban areas with high yielding varieties, implementation of good agricultural practices, improvement of farmers-industry partnership, plant protection, intensification and diversification, micro-propagation through embryo and tissue culture. The objectives of this review is to provides (1) an overview of the present status of coconut development in Indonesia, (2) the challenges and opportunity to increase productivity and improve framer’s income, and (3) outlook of coconut development toward 2045.

2. Area and Yield Gap in Production of Coconut

Coconuts are cultivated in ca. 3.4 million ha of land throughout 34 provinces of Indonesia, producing ca. 14.3 billion nuts or ca. 2.85 million MT copra per year in 2017. Riau Province in Sumatera Island has the largest area (12.14 %), followed by North Sulawesi (8.11 %), East Java (8.06 %), Central Java (6.49 %), North Maluku (6.31%) and Central Sulawesi (6.29 %) (Figure 1). However, 406,693 ha or 11.7% of the palm age on the coconut plantation are categorized to senile, 405,100 ha or 13.38% categorized to immature and 2,603,754 ha or 74.92% of the plantation categorized to mature (Directorate General of Estate Crops, 2018). In 2019, there is a slight increase of coconut area to ca. 3.5 million ha compared to the previous years (Figure 2).

A yield of more than 2.8 MT copra per ha/year and 3-4 MT copra per ha/year for superior coconut tall varieties and hybrid varieties, respectively under ideal management has been recorded at research Institutes. However, the average national production is only about 1.1 MT copra / ha / year. There is no significant increase in the production’s growth rate under national level. Factors directly affecting low productivity are high proportion of aging palms; pest and disease attack, lack of maintenance, use of inferior varieties and conversion of land to more valuable crops. Financial constraint is one of the main reasons why farmers did not properly manage their coconut land and replant the aging palms.
Indonesia has been widely known as the country with high diversity of coconut germplasms. There are more than 90 coconut accessions that have been selected and collected in the International coconut gene bank (ICG) located both in Indonesian Palm Crops Research Institute (IPCRI) and The Assessment Institute for Agricultural Technologies in North Sulawesi. Ca. 40 of them were officially released as national superior varieties and local superior varieties (Table 1). About three trials of coconut hybrids are under testing in IPCRI. However, only few certified coconut seed gardens are available as source of selected and certified seeds in Indonesia.
| No. | Variety                        | Important Traits          | Origin          |
|-----|--------------------------------|---------------------------|-----------------|
| 1.  | Mapanget Tall (MT)             | High yield                | North Sulawesi  |
| 2.  | Tenga Tall                     | High yield                | North Sulawesi  |
| 3.  | Bali Tall                      | High yield                | Bali            |
| 4.  | Palu Tall                      | High yield                | Central Sulawesi|
| 5.  | Sawarna Tall                   | High yield                | North Sulawesi  |
| 6.  | Kima Atas Tall                 | High yield                | East Java       |
| 7.  | Banyuwangi Tall                | High yield                |                |
| 8.  | Jepara Tall                    | High yield                | Central Java    |
| 9.  | Lubuk Pakam Tall               | High yield                | North Sumatera  |
| 10. | Rennel Tall                    | High yield                | Nusa Tenggara Timur |
| 11. | Takome Tall                    | High yield                | North Maluku    |
| 12. | Sikka Tall                     | High yield                | Jogyakarta      |
| 13. | Bojong Bulat Tall              | High yield                | Gorontalo       |
| 14. | Kramat Tall                    | High yield                | Gorontalo       |
| 15. | Molowahu Tall                  | High yield                | Nusa Tenggara Timur |
| 16. | Adonara Tall                   | High yield                |                |
| 17. | Panua Tall                     | High yield                | Gorontalo       |
| 18. | Mastutin Tall                  | High yield                | Nusa Tenggara Barat |
| 19. | Sri Gemilang Tall              | Swampy tolerant           | Indragiri Hilir |
| 20. | Kopyor Puan Kalianda Tall (KPK)| Semi Tall                 | South Lampung   |
| 21. | Buol St-1                      | dwarf                     | Central Sulawesi|
| 22. | Nias Yellow Dwarf (GKN)        | Dwarf                     | Nias, North Sumatera |
| 23. | Bali Yellow Dwarf (GKB)        | Dwarf                     | Bali            |
| 24. | Salak Dwarf (GSK)              | Many nuts per bunch, dwarf| South Kalimantan|
| 25. | Raja Dwarf (GRA)               | Dwarf                     | North Maluku    |
| 26. | Kopyor Green Dwarf             | Soft endosperm            | Pati, Central Java |
| 27. | Kopyor Brown Dwarf             | Soft endosperm            | Pati, Central Java |
| 28. | Kopyor Yellow Dwarf            | Soft endosperm            | Pati, Central Java |
| 29. | Kopyor Puan Kalianda           | Soft endosperm            | Lampung         |
| 30. | KB-1 (MT #32 x MT #32)         | High yield                | IPCRI           |
| 31. | KB-2 (MT #32x MT #2)           | High yield                | IPCRI           |
| 32. | KB-3 (MT #32 x MT #83)         | High yield                | IPCRI           |
| 33. | KB-4 (MT #32 x MT #99)         | High yield                | IPCRI           |
| 34. | KHINA-1 Hybrid                 | High yield                | IPCRI           |
| 35. | KHINA-2 Hybrid                 | High yield                | IPCRI           |
| 36. | KHINA-3 Hybrid                 | High yield                | IPCRI           |
| 37. | KHINA-4 Hybrid                 | High yield                | IPCRI           |
| 38. | KHINA-5 Hybrid                 | High yield                | IPCRI           |
| 39. | Red Cungap                     | High antioxidant          | Banten          |
| 40. | Bido Tall                      | High Yield, Early bearing | Morotay, North Maluku |

Source: [11], [12][13]

Collection of coconut germplams with high yield potential and other desirable traits is important not only for source of planting materials but also for breeding to generate hybrid. Coconut germplams collection was established in Indonesia, mostly in experimental gardens of IPCRI located in North Sulawesi. The major mandate of a gene bank is for conservation of coconut germplasms and...
providing genetic materials for uses in generating high quality and certified seed nuts so that stakeholders either public or private sectors can benefit from this material, reproduce it and disseminate them to the final users [14]. Hybrid coconuts can potentially increase coconut yield, but no data are available on the distribution area of the hybrids and its impact on the average national production.

Intensification has been done through distribution of released varieties for replanting program, and implementation of poly-culture planting system through intercropping with food crops, horticultural crops or livestock. Poly-culture to utilize effectively space between palms, such a system will also optimize use of sunlight, soil, water and labour. Coconut-based farming system is the integration of natural resources, agricultural inputs, human resources in more productive and profitable ways. In monoculture system, the land use effectively by coconut palms is only about 25%. In coconut palm plantation, natural resources such as sunlight, water and nutrients can be utilized by intercrops without reducing main crop yield. Growing of intercrops in coconut plantations produce more foods and agricultural products, which are important for food security in rural and urban areas, generate jobs, improve farmer’s income and the purchasing power of people and thus alleviating poverty in coconut-based farming system. Growing intercrops could help in the conservation and management of plant genetic resources, favor the diversity of soil microflora, higher biomass generation and recycling over a period of time.

The success of poly-culture system in coconut-based farming system is affected by a number of factors including the architecture and rooting system of crops, availability of sunlight, selected crop types adaptable to local climatic and soil conditions, tolerance to shade, availability of irrigation, sociocultural factors of the farmers, economic competitiveness of the crops and marketing facilities of the products [15]. IPCRI has recommended to adopt a suitable spacing of coconut, a wider planting distance of 6 m X 16 m for facilitating inter/mixed cropping and the best results of the intercrop production. IAARD has released several upland rice varieties tolerant to up to 60% of shade.

Pests and diseases are limiting factors for improving coconut production. Major pests and diseases attacking coconut palms in Indonesia including Coconut Rhino Beetle (CRB) (*Oryctes rhinoceros*) [16], hispid beetles (*Brontispa longissima, Plesispa reichei*), *Sexava* spp., and bud rot and nut fall diseases [8,17–20]. In Indonesia alone, yield losses and management for major coconut pests and diseases can cost up to Rp. 1.2 trillion per year.

Component technology to control major pests of coconut are available [8] but sometimes are not powerful enough to reduce the pest population and sustain the economic level. Hence, innovations in pest control are highly demanded to suppress the development of pest populations in the field. Integrated Pest Management (IPM) conception has been recently proposed to combine various control approaches and provide appropriate diagnosis of pests and disease.

3. Product Diversification and Export

Coconut products produced and traded in Indonesia for local consumption and as exported products are derived from coconut shell (Coconut Coir, Coir Yarn, Coco peat, and mat), coconut water (coconut Drink, Nata de Coco, Coconut Vinegar, and Coconut Sauce), coconut meat or endosperm (coconut oil, Virgin Coconut Oil, coconut flour, coconut milk, coconut Butter, Copra, and Young tender Coconut meat), coconut shell (charcoal, activated carbon, handcraft), coconut husk (doormats and car seat fillers), and coconut stem (Furniture and house).

The primary coconut products traded internationally are still derived from traditional products with the total export of coconut and derivative products in the terms of January-June 2018 is US$ 1.32 Million or equivalent 2.17 Thousand Tons. The export of coconut declined compared to 2017, which amounted to US$ 1.41 Million or 2.31 Thousand Tons (Figure 3). There is a change in the composition of our main export product. In 2017, our top five export products were coconut oil ranks the first in terms of earnings from export, followed by crude coconut oil-copra, desiccated coconut, fresh coconut and charcoal. But then, in 2018, our top five export products were coconut oil, crude coconut oil, desiccated coconut, charcoal and coconut meat. Export for fresh coconut has declined. The shifting for the export products caused by trade barrier in some of Indonesia’s export destinations such as implementing specific standard. Regular copra, whose price is lower than those other
valuable coconut products, is still the major product produced by farmers in some provinces such as North Sulawesi and Maluku.

In terms of earnings from export in 2018, our top five products in 2018 were coconut oil in the first (US$ 371.9 Million), with the main market of coconut oil from Indonesia is People’s Republic of China. Followed by crude coconut oil-copra (US$ 354.7 Million) which with Netherlands, Malaysia, and United States as its main market. During 2018, Asia and Europe were still the main market for Desiccated Coconut from Indonesia. The two regions absorbed 82% of total export volume of Desiccated Coconut from Indonesia. In Asia, Singapore is the main hub for Indonesian Desiccated Coconut manufacturers. More than 22% of total Desiccated Coconut was exported to or via Singapore. Europe was the second largest market for Desiccated Coconut from Indonesia in that period. Whilst, other products such as charcoal (US$ 155.6 Million) are exported to South Korea, India, and Vietnam, and coconut meat (US$ 64.8 Million) are exported to Malaysia, Thailand, People’s Public of China, Pakistan, and Sri Lanka.

The market shared of copra tended to decline. Future market of coconut would be dominated by health oriented products. It has a good market positioning and benefit from the “extensive” method of cultivation of coconut trees. The renewed interest of major players in the food sector is tropical lauric oils (non-hydrogenated oils, thus having no trans fatty acids and whose physicochemical and nutritional properties come from a natural fatty acid profile and raw composition in microelements) [14]. Significant external factors that affect exports of coconut products are foreign income [21].

4. Profile of Coconut Industries

The income of the coconut farmers can be enhanced not only by increasing production, but also by value addition, and better marketing options [22]. The performances of coconut industries would be affected by how efficient value chains can strengthen the value-adding activities by better technology and inputs, upgraded infrastructure and processing and exports [23]. Increasing farmer’s income can be predicted from the implementation of various programs to increase production and increase added value. Therefore, industry performance is important to consider in increasing farmer’s income.

Data on the availability of coconut industries in Indonesia is still limited. Data presented here is only for medium and big industries. About 87 industries that consist of coconut oil, integrated industries, desiccated coconut and carbon industries recorded in The Ministry of Industry. All of these industries are located in Sumatera, Java, Sulawesi and Kalimantan.
Table 2. Major Coconut Industries Producing Main Exported Coconut Products in Indonesia

| Region   | Types of Industry |
|----------|-------------------|
|          | CNO | Integrated | DC | Carbon |
| Sumatera | 8   | 4          | 14 | 9       |
| Java     | 9   | 1          | 2  | 10      |
| Sulawesi | 5   | 2          | 13 | 3       |
| Kalimantan | 4  | -          | 1  | 2       |
| Total    | 26  | 7          | 30 | 24      |

Source: HIPKI, 2019 (Processed by Ministry of Industry).

Total production based on type of coconut industries in 2017 is 382.34 Thousand Tons with the top three coconut industrial products are Coconut Cream 122.9 Thousand Tons or 32.15%; Charcoal 96.3 Thousand Tons or 25.20%; and Oil Cake 30.5 Thousand Tons or 7.99%. Lack of some data of coconut industries might be addressed by new application being developed by The Ministry of Industry to collect industry-related data namely National Industry Information System or in Bahasa Sistem Informasi Industri Nasional/SINas). Through this application, more accurate data might be available in real time.

Market opportunities for coconut products continue to develop due to health reasons and environmental issues that affect the pattern of demand and consumer preferences [23]. Prospective product for the development of integrated coconut agroindustry in Indonesia are coconut oil, coconut milk, coconut sugar, nata de coco, handicraft industry, copra, VCO, coconut fiber, desiccated coconut, and shell charcoal. The criteria used to analyze are the availability of raw materials, employment, technology used, value-added products, environmental impacts, market opportunities, product quality, product distribution, and government policies [24].

5. Programs for Increasing Coconut Production and Improving Farmer’s Income

IAARD through IPCRI develops a program to increase coconut production and improve farmer’s income. The program includes identification and marking of coconut mother palms for production of quality planting materials, development of a protocol for tissue and embryo culture, promotion of Good Agricultural Practices and the introduction of high value crops in coconut plantations to enhance the income generation of the smallholder farmers. National programs for improving coconut production and productivity include (1) distribution of certified seeds for promoting replanting, use of high yielding varieties, which were legally released by the Ministry of Agriculture and certified as superior varieties (Table 1); (2) establishment of the seed gardens for quality planting materials; (3) promotion of a good agricultural practices; (4) management of major pests and diseases; (5) development of a protocol for tissue and embryo culture. Distribution of coconut seedlings by a number of government institutions under the Ministry of Agriculture to coconut smallholders has been done since 2017 to 2018 through a program called “seedling program”, and then in 2019 to 2023, the Ministry of Agriculture will continue to provide farmers with ca. 5 million seedlings of estate crops including coconuts to replant the senile palms, through a program called “bun500”. In this program, the Directorate General of Estate Crops will establish coconut seed gardens in several major coconut producing provinces.

Providing the best quality of coconut seedlings to farmers was considered important since the full potential could be achieved only with proper planting material. A comprehensive evaluation for coconut distribution programs either for those had been implemented or for the plan of the next program is crucial for the best result for sustainable coconut development. Indonesian Agency for Agricultural Research and Development (IAARD) through Indonesian Palm Crops Research Institute (IPCRRI) in collaboration with local government has released ca. 40 superior coconut varieties, including tall, dwarf and hybrid coconut varieties since 1984 (Table 1). Coconut production could be increased through collection and sharing of germplasms, the rejuvenation of the ex situ collections with coconut varieties having desirable specific traits like resistance to major pests and diseases, high
oil content, dumpy types, and adaptive to suboptimal land, and micro-propagation through tissue culture [25].

IPCRI has established seed gardens for quality planting material and varietal improvement through controlled pollination. Tissue culture, which includes embryo culture, cryopreservation and somatic embryogenesis is one of the important solutions for providing adequate number of high quality of coconut seeds especially for the elite types (kopyor and aromatic coconut) for both farmers and industries. The objective of somatic embryogenesis of coconut is to obtain multiple clonal copies of the parent plant. It involves some process such as induction, which is the production of embryogenic callus from explants, the multiplication of the embryogenic callus, the development of somatic embryos and germination of the somatic embryos into plantlets. The constraints typically experienced are numerous but some of them include tissue browning, inefficient proliferation and low rates of plantlet regeneration.

Poverty of coconut farmers might be caused by volatile commodity price, narrow product line (copra is the main product produced by farmers), low product quality, unfavorable supply chain, monoculture-planting system, and small area owned by each farmer. The area of coconut is mostly owned by smallholders (99.37%) [1]. Integration of other crops (food crops, horticultural crops or other estate crops) and coconut, or livestock and coconut could enhance the income generation of the smallholder farmers. IAARD has generated several paddy varieties, which are tolerant to shading (up to 40% shade), and suitable for the integration with coconut palms.

IAARD has also has set up learning centre or centre of excellence in Manado (IPCRI) from downstream aspects of coconut to the upstream one. Creation of awareness on coconut products and by-product utilization has been carried out through a number of media including coconut working groups, coconut festivals in counties and a national coconut conference (KNK) and the appointment of a technical working committee for revitalization of coconut subsector.

6. Outlook of coconut development toward 2045

The outlook for the coconut product market is extremely positive and global market demand for coconut products tend to increase. The global coconut ingredient market value was expected to grow at a annual growth rate of 11.3%, and the global coconut ingredient market volume was expected to grow by 79.9%. Data from Franklin Baker and Co. Philippines showed that demand by volume for coconut water, coconut milk, VCO, and DC were increased about 149%, 54%, 33%, and 29%, respectively.

Organic-based products tend to increase also in line with the rising health awareness among people. Consumers look for pure, natural products free from synthetic chemical ingredients. People tend to avoid gluten and transfat and genetically modified products. Inclusion of healthy ingredients is encouraged. To meet rapidly increasing coconut products demand, national production, productivity and industries manufacturing those products would have to be higher than that from previous years.

Agricultural research is the key for ensuring increase in production and productivity as well as product diversification technologies, which are more efficient. Advanced technologies in molecular to accelerate breeding program on generating superior varieties, micro-propagation of coconut through embryo culture and tissue culture, eco-friendly pest and disease management technologies, good agricultural practices, and advanced technologies for swampy areas might be possible to meet local and global need above.

Number of industries in Indonesia manufacturing Crude Coconut Oil (CNO), DC, Carbon and other coconut products is ca. 87, distributed in Sumatera, Jawa, Sulawesi, and Kalimantan (HIPKI, 2016, Ministry of Industry). Farmers and industries produce various coconut products stemmed from its various parts such as coconut water, coconut meat, husk and shell. Most of coconut farmers produce ordinary copra whose price is less than the white copra. Other value added products mostly produced by industries include coconut water, coconut milk, coconut nectar, coconut honey, coco aminos, desiccated coconut (DC), virgin coconut oil (VCO), Nata de coco, MCT oil, activated carbon, shell charcoal, coconut sugar, geotextiles, coco logs, soil mulch, mattress, brush, gardening materials, and coco wood furniture. Some products manufactured from coconut oil include fatty acids, methyl esters, fatty alcohols and glycerine. From which a number of nutraceutical and cosmetics products are
produced. Collaboration between industries and farmers community through a fair trade need to be promoted. The issues of uneducated and unorganised farmers need to be addressed through capacity building program, establishing farmer groups with legal status and improving farmer’s facilities in producing coconut products.

7. Conclusion

Productivity and average national production of coconut as the tree of life is still low. Program for increasing production includes the use of quality planting materials, build certified coconut seed gardens for replanting the unproductive palms, micro propagation of elite types of coconut through tissue and embryo culture, and promotion of Good Agricultural Practices, as well as management of pests and diseases. Introduction of high value crops in coconut plantations to enhance the income generation of the small holder farmers Coconut and its products would contribute to enhance farmer and national income, meet people’s need on healthy oil, food and beverages, and generate employment at rural villages and industrial level. The demand of coconut and its products tend to increase in line with the growing increase of human population and global market need. It is recommended for government to include sustainable coconut development as a national priority program in order to meet the demand, enhance dissemination of innovative technologies to farmers, capacity building for smallholder farmers, promote local consumption of coconut-based products, increase number of manufacturing industries in major coconut producing regions to produce marketable and profitable coconut products, and increase the synergy between farmers and industries.

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