Innovation policies to foster sustainable and resilient rice production in Indonesia to meet current demands and future needs of a top five global economy

This essay is based on:

- **Briefing option 1:** The Minister requires a briefing on specific innovation policy instruments and their potential role in supporting innovation to deliver the SDG target you have selected. You should draw on the literature and on evidence of policy instruments that have been applied across the world, but target your briefing at a particular national context of your choosing. Please specify the country context in your briefing.
- **Target 2.4:** By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
- **Country:** Indonesia

Introduction

Indonesia is both a developing country (based on ODA criteria) and a G20 member and is expected to be a top five economy by 2045 (Sekretariat Kabinet Republik Indonesia, 2017). This presents an interesting case study for innovation policies for sustainable rice production in order to meet the "needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p.41).

The briefing provides an overview of technology policy iterations since Dutch independence, provides an understanding of the rationale for "self-sufficiency" based on the Asian financial crisis of 1997, then, goes on to highlight gaps in framings such as incorporating future demographic and development changes into the innovation policy mixes. The briefing challenges the current innovation policy status quo to ensure Indonesia is prepared for transformative changes for low-input high-yield rice production using "environmentally friendly technologies".

Framing sustainable, resilient, and "self-sufficient" rice production in Indonesia

Of the three key dimensions of sustainability (environment, economic and social) the economic and social dimensions have received much more attention and guided policy framings in Indonesia than the environmental impacts of rice production. However, recent framings have focussed on resilience and climate adaptation, this is evident in investments in creating "modern varieties of rice" which are more climate resistant (International Rice Research Institute, 2018) and combination of economic policy instruments which aim to protect agricultural livelihoods against stresses and shocks, this has been most acutely demonstrated during the national stimulus packages during the recent Covid-19 pandemic (OECD, 2020a, p.293). Current policy aims to address the impacts of climate change rather than contribute to reduction of GHG (greenhouse gas) emissions – this is evident by the absence of any GHG reduction targets for sustainable agriculture in Indonesia's Nationally

Determined Contributions (NDCs)(OECD, 2020a, p.293). Thus, Indonesia is at risk of not meeting planetary boundary targets (Steffen et al., 2015). The key framings and future considerations are summarised in the table below.

Table 1: Summary of sustainable framings for rice production in Indonesia with assessment of future considerations.

	Framings	Future considerations
Economic	Protecting agricultural livelihoods and "self-sufficiency" against global price shocks. Agriculture employs 78% of the poor (Mariyono, 2014), rice price is an important determinant to inflation and economic stability.	Indonesia may be a net exporter of rice in the future due to demographic and economic change and current targets of 5% annual increase in production (Faisal et al., 2019).
Social	Access to affordable staple food such as rice attributed to significant development gain and meeting the needs of the most marginalised. However, in 2018, 30.8% of Indonesian children under 5 were remained "stunted" (Ministry of National Development Planning/ National Development Planning Agency, 2019, p.13).	As Indonesia gets richer diversity of food preference will make rice less important as a staple diet.
Environmental	Low input and environmentally responsible methods could lower production costs. Land use change into industrial sites could further increase GHG emissions. World Bank (2008) estimated that Indonesia was the third largest GHG emitter in 2007, with agriculture the dominant contributor of methane (at 59%) and rice cultivation at 70% of agricultural methane emissions.	Possibility of climate-smart crop innovations responding to needs of tropical rice production, specificity of soil, geo-location markers, theoretical maximum yield becomes more important. (Austin, 2019; International Rice Research Institute, 2018).
Cross-cutting framing: political / health	Access to affordable staple food is a highly political matter on which elections can be won or lost and cause potential instability (Mariyono, 2014).	Excess rice consumption linked to increased risk of disease such as diabetes, requires change in framing to promote diverse diets (Takahashi and Barrett, 2013).

How has Indonesia developed its technology policy mixes until now?

Indonesia has experimented with a variety of policy mixes to enable it to achieve food "self-sufficiency". Since independence, successive governments have coordinated polices mixes for rice production through investments in irrigation, research and development (R&D) leading to adoption of "Green Revolution" technologies. Recently, trade regulation, pricing policies and subsidies have been increasingly deployed (Wardana et al., 2018).

Policy mixes are techniques used by governments to enable it to achieve behavioural outcomes – both positive and negative (Edmondson et al., 2019). Since Dutch independence, Indonesia's rice production and yield have been marked by five distinct innovation policy mixes (Wardana et al., 2018) as outlined in Table 2. Rapid growth took off from 1973 onwards fuelled by foreign exchange receipts of booming oil prices (back in Indonesia was still a net exporter of crude oil), this led to large investments in irrigation

networks as well as research and development into high yield varieties and techniques, farm financing and high-input "Green Revolution" subsidies (Simatupang and Timmer, 2008).

The slow growth emerged as a result of unsustainable subsidy support as well as over-use and misuse of fertilisers which led to decrease in soil quality and over-intensification leading to overall 4% reduction in productivity from 1991 - 1997, further disrupted by El Nino weather patterns leading to droughts (World Bank, 2008).

Following both economic and environmental crises, the government advocated for more "environmentally friendly" policies such as integrated crop management (Mariyono, 2009), reduction of inappropriate fertiliser use (by gradually decreasing fertiliser subsidy) and decentralising implementation of policies to regional provinces (Simatupang and Timmer, 2008).

Table 2: Five distinct phases of technology policy mixes in Indonesia since Dutch independence, summarised from (Wardana et al., 2018).

Stage	Technology policy mixes	Impact
Consolidation (1969 – 1974)	• Modern varieties of seeds • Inorganic fertilisers	• Increased food security • Reduced poverty
Rapid Growth (1974 – 1987)	• Increased fertiliser use	• Self-sufficiency in rice • Soil and water pollution
Slow growth (1987 – 1997)	• Decrease fertiliser use • Integrated Pest Management (IPM)	• Increased rice imports • Income for farmers slowed
Economic crisis (1997 – 2001)	• Balanced Fertiliser use	• Increased dependence on government subsidies
Decentralisation (2001 – present)	• Select modern varieties • Integrated Crop Management (ICM) • Bio-fertiliser	• Increased support from local government • Multi-channel dissemination of technology • Efficient input use • Price stabilisation

Current Indonesian policy context

The current objectives for rice policy have been driven by ideals of "self-sufficiency", this is due to the volatile nature of international price mechanism of rice, where only 5% of the global rice production is tradeable (Statista, 2020), this causes significant price fluctuation and dependency in a small number of countries involved in global rice production. This combined by increasing demand driven by population growth means that importing rice becomes very expensive for Indonesia (in some case 10% of GDP) and vulnerable to shocks such as the 1997 Asian Financial crisis and the El Nino weather disruptions. Thus, the main determinant of policy is the ability of domestic rice production to meet consumer demand (Simatupang and Timmer, 2008).

According to Mears (1984), self-sufficiency in rice production entails four key components:

1. Floor price (min price) such that it is high enough to incentive production to meet demand
2. Ceiling price (max price) for consumers to prevent hardship / political instability
3. Range of the price allows for profitability
4. Range of the price is comparable with international markets

The implementation of floor-ceiling prices is managed by a state owned agency (BULOG) which is responsible for buying rice during excess supply (to increase price from a min of USD 347/tonne) and selling large quantities on the market (to decrease price from USD 348/tonne), so that overall, rice prices remain stable, as has been the case since 2005 (OECD, 2020a, p.302), though, considered much more expensive than global prices (OECD, 2015). Additionally, Indonesia maintains restrictive import policies on rice, so that only BULOG can import rice (in order to meet its targets under the price ceilings), this forms the "rice price support" policy to sustain the agricultural industry (Simatupang and Timmer, 2008).

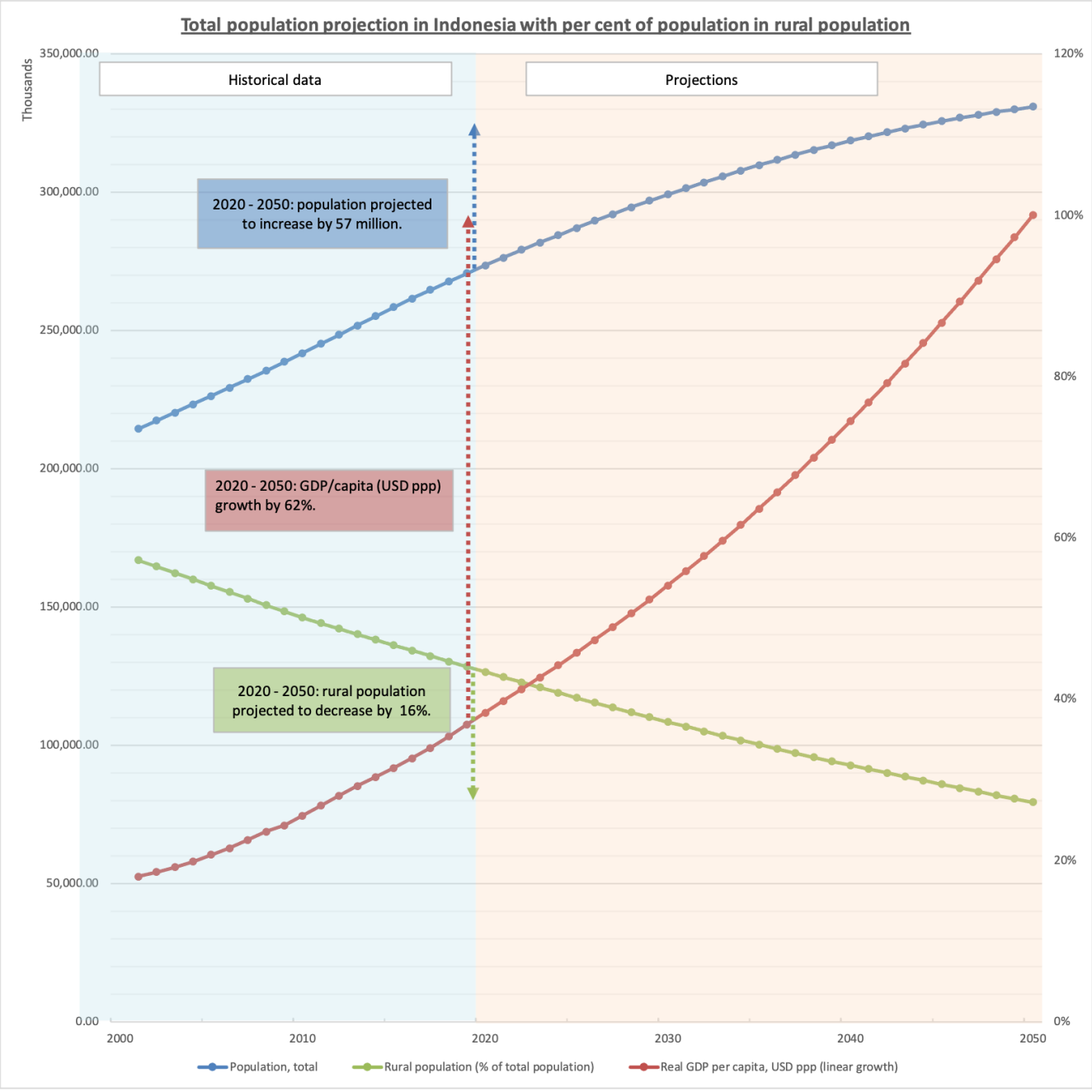
Challenges in sustainable rice production

1. Balancing current demand with future needs

In Figure 1, I have taken both historical and projected data of population and GDP/capita from World Bank and OECD to highlight how current policy of self-sufficiency is unsustainable for future needs. The below graph has several implications, it predicts that Indonesia's population will grow by 57 million by 2050, however, the share of rural agriculture will reduce by 16% over the next 30 years, this means that the agricultural sector will face labour shortages as well as competition with urbanisation (Mears, 1984).

However, the 62% gain of GDP/capita in the next 30 years has several policy implications. FAO (2018, p.68) analysis suggests that as incomes increase, there is also a shift away from carbohydrate (staple foods such as rice) towards meat and premium vegetable consumption. This means that Indonesia should focus on diversifying agricultural produce as demographic shifts change food preferences.

Figure 1: Projected growth of population, share rural population and GDP/capita. Population data are from World Bank (2019), GDP/capita data are from OECD (2020b) projections. Left Y axis show population in thousands, right Y axis shows per cent.



2. Price support leading to environmental degradation

The agricultural sector, like many other countries, is of strategic importance, thus is protected by support mechanisms. However, excessive support to fertilisers has led to over-use and in some cases misuse leading to reduction of soil fertility and contamination of water supplies (World Bank, 2008). This is attributed to excessive subsidies for fertilisers without much support to farmers on appropriate application (Mariyono, 2019).

3. Challenge in scaling up due to weak governance and lack of systematic R&D investment

The table below provides examples of sustainable "high-tech" and "low-tech" innovations currently occurring within the Indonesian rice sector (Triguero et al., 2013), however, critical review of innovations within the sector indicates that coordination efforts due to excessive decentralisation (World Bank, 2008) is the key bottleneck preventing scaling up and outscaling in order to break through the innovation niche into wider adoption (Hermans et al., 2013). As the table below demonstrates, indigenous innovation techniques such as the Logwo Jajar planting system and the SALIBU rice cultivation methods can combine with modern knowledge systems to enhance yield close to the maximum potential. Therefore, bottom up processes, using grassroot entrepreneurship and local knowledge systems can help deliver solutions to sustainable agriculture (Sarkar and Pansera, 2017), but these must be supported and encouraged by central policy.

Table 3: Examples of sustainable rice innovations occurring in Indonesia.

Examples of sustainable rice innovation occurring in Indonesia	
Modern Rice varieties **(High-tech)**	• **Rice varieties tolerant to stress-prone ecosystems** such as coastal areas affected by salinity and oceanic processes. Flood and salinity resistant varieties demonstrate yield advantage of up to 125% over popular varieties (Rumanti et al., 2018). • **New superior varieties (VUB) -** Lowland rice has higher yield than local varieties. Ministry of Agriculture is supporting roll out of 100 new varieties (Faisal et al., 2019).
Technique based innovation **(Low-tech)**	• **Logwo Jajar planting system** use spacing techniques to optimise rice production allowing for maximum space and sunlight. Possibility for production of 13.9 tons / ha when combined with VUB, bio-fertilisers, balanced soil test equipments (PUTS) and control of plant pests (OPT) (Faisal et al., 2019). • **System of rice intensification** (SRI) - pioneered by Henri de Laulanie stationed in Madagascar in 1961, the idea behind SRI is to increase efficiency of inputs, improve fertility of soil and enhance techniques to improve productivity (SRI-Rice, 2018). • **SALIBU Rice Cultivation** – indigenous cultivation technology based on emergence of shoots after harvesting of crops, if shoots exceed 70% of cutting then the parent plan is retained yielding 3.5-4 times harvest per year. Benefits include reduction of inputs such as water, labour and growth period (Fitri et al., 2019). • **Planting calendar** – adapting to unusual weather patterns to provide the best chance of harvest cycles throughout the year (Faisal et al., 2019).
Rice farm insurance (Financial)	• **Insurance for farmers** against losses from droughts, floods, pests and disease infestation (Pasaribu, 2010).

Policy mixes for transformative change

To shift towards sustainable agricultural practices, Indonesia should widen transformative change in its policy mix. This is because the rice sector is central to all three dimensions of sustainability and has fundamental consequence in each of these domains – on economic dimensions, rice prices can set inflationary rates, on social dimension, rice is the dominant cultural diet and on the environmental dimension, the ability of the sector to respond to climate impact determines the long-term viability of a profitable industry. Thus, power and politics play a large part in ensuring that the wider agricultural sector is viable and serve the demand of current and future needs (Scoones et al., 2015, p.3).

However, as Scoones et al. (2015) note, transformations are contested, occur along multiple pathways and interconnect. To effect any transformation, narrative and framings must be essential. In technocratic transformations, there is shift towards lower carbon energy and lower inputs leading to higher yields, the emphasis here is on the "right kind of technologies" which improve the ecological footprint without altering systems fundamentally. This is the current policy framing, however, in practice transformations have been state-led with market-like mechanisms (e.g., rice pricing support) to effect maximum social control and recent framings have coupled low carbon growth pathway narrative with economic growth, the current government claim such transformation will average GDP growth of 6% per year until 2045 (National Development Planning Agency, 2020, p.11).

Future policy should galvanise "green transformation from below" (Scoones et al., 2015, p.102) by mobilising local context specific innovations via "grassroots ingenuity" (Fressoli et al., 2014), this is particularly important as any gains in maximum yield for rice production is not blanket use of modern technologies, instead it will need to be bio- and geo-specific e.g. to soil type, season and weather patterns as well as local demands for rice varieties (FAO, 2018). This is indeed the case for indigenous techniques developed such as the SALIBU cultivation method for multiple harvests of the same parent plant and the Logwo Jajar planting system to maximise spacing for sunlight (see Table 3) – both types of innovation are location specific and arose from indigenous know-how and are recognised as low-input high yield methods.

With this transformative policy change in mind, to better coordinate decentralised administration, scale grassroot innovation and improve the sustainability footprint of the rice sector, the table below critically assess policy instruments according to the typologies illustrated by Borras et al. (2010) – see Table 4.

Table 4: Selected policy instruments for sustainable rice production in Indonesia.

Category	Example of instruments	Critical assessment
Regulatory	• Relax import tariffs to increase production efficiencies. • Commit to Nationally Determined Contributions (NDC) for agriculture • Enhance patenting for indigenous technologies and enforcement of intellectual property (IP) rights.	• Rice price market is (artificially) more expensive than international markets due to policy - this limits innovative potential at production level (OECD, 2015). • There are no binding NDC's for agriculture – Indonesia should commit to the National Plan to reduce GHG for agriculture by managing land use, reduce burning and reforestation (OECD, 2020a, p.293). • High-tech innovative capabilities emerge from multinationals operating in Indonesia, with their local subsidiaries having limited capability for local adaptation, additionally, low patenting output from agricultural sector is compounded by weak enforcement (OECD, 2010, p.188).
Economic	• Increase R&D spending specifically for universities and public agricultural research centres. • Reduce input subsidies and maintain specific output subsidies.	• In 2010, it is estimated that only 0.08% of GDP was spent on public R&D (Lakitan, 2013), this is lower than comparable Southeast Asian countries (OECD, 2010 and OECD, 2016). With 80% of R&D undertaken by the government, contrasted with the US where 70% are undertaken by industry (Lakitan, 2013), the 5% share of universities undertaking existing R&D (OECD, 2016) should be enhanced, particularly those allied to agricultural research whilst also avoiding elite "ivory tower" syndrome (Lakitan, 2013). • Removal of fertiliser subsidies could enhance efficiency gains (by reducing input costs and more frugal use of fertilisers), however, this has to be balanced by overall profitability and likely increase in labour costs due to urban migration (Simatupang and Timmer, 2008).
Soft	• Enhance coordination of decentralisation policy • Behavioural change	• Centralised coordination was effective during the 1970s oil boom fuelled investments and subsequent "Green Revolution" technologies. However, decentralisation was more effective in diffusing modern techniques. Excessive decentralisation and lack of effective coordination functions led to loss of strategic capabilities and ability to transfer best practice quickly e.g., environmentally friendly technologies (Mariyono, 2009). • Policy should promote diverse diets to decrease large demands on rice (FAO, 2018).

International and inclusive dimension

Globally, only 5% of rice production is traded and international supply originate from three rice exporting countries: Thailand, India, and Vietnam, therefore, changes in trade policies of these countries lead to large price fluctuations. In terms of global production, Indonesia ranks third after China and India due to meeting local demands, it is currently a net importer in order to meet reserve conditions (Indonesia Investments, 2017). Although rice is seen as the dominant staple diet across Indonesia, this is not the case for West Papua where "integration efforts" have proven controversial. Rice intensification, replacing traditional diets, has led to conflicts with Papuans, thus, highlighting that one-size does not fit all.

Conclusion

To meet SDG 2.4, where, by 2030, Indonesia can ensure sustainable food production systems, which is resilient and mitigates against adverse environmental impact, Indonesia needs to prioritise innovation policies leading to transformative changes towards low-input high yield productivity. The policy mixes presented are based on a deep understanding of how the current policy mix has come about and the narratives which underpin the objectives of sustainable rice production.

Transformative policy changes must consider the different scales of innovation (from farm level production to international trading), spatial contexts of different soil, weather, and seasonal patterns as well as governance measures. Critical reviews have identified whilst Indonesia has been able to improve yield and productivity during the good years (early 1970 fuelled by oil price boom) it has been slow make the most of "environmentally friendly" technologies which rely on "low-tech" techniques coupled with indigenous knowledges systems. The future of sustainable rice production will rely on diffusion of innovation practices on the supply side but also changing demand preferences by promoting diverse diets, this has the dual benefit of sustainable production as well as future health benefits by decreasing the incidence of diabetes linked to predominantly carbohydrate-based diet.

To sum up, the rice economy is of strategic importance in most Asian economies where rice is the dominant diet, especially when affordable and accessible rice can be a pathway towards achieving nutrition for the most marginalised and poor. However, as demographic and economic contexts of developing countries change, it is important to re-evaluate existing policies which favour current demands over future needs. This is most acutely observed when mitigating against shocks and stresses to the system, most recently observed during the Covid-19 pandemic, however, long-term environmental considerations must ensure that the national system of innovation in Indonesia can produce climate resistance varieties of rice and cultivation methods to ensure that yields can be maintained and reduce input costs.

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