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The Role of Extension in Activity-Based Adaptation Strategies towards Climate Impact among Oil Palm Smallholders in Malaysia: A Systematic Review

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Abstract: *Adaptation is a key strategy that can alleviate the harshness of climate change impacts on farming. Adaptation strategies are probably not going to be viable without an understanding of the nature of the impact. Climate change causes higher precipitation fluctuation and less reliable precipitation due to extended drought periods and extreme precipitation that will adversely affect oil palm production. In Malaysia, the common effects of drought stress are: (i) increase of abortion; (ii) failed or rotten bunch; (iii) fluctuated and low productivity; and (iv) long inflorescences (8-9 months). In addition, excessive rainfall usually reduces road quality, inhibit harvest activity, and flooding. High precipitation and humidity also cause severe destruction to fresh fruit bunches. There are several activity-based adaptation strategies dealing with climate change, i.e. planting material tolerant to extreme rainfall, applying soil and water conservation, reducing water evaporation by weed/cover crop management and mulching, and several agronomic practices to reduce evapotranspiration before the dry season. Implementing. In order to achieve this, extension services play an important role in educating farmers by encouraging them to learn, adopt new technologies and spread them to other farmers. To ensure the success of the extension program is through understanding their roles as, Technology and information managers, Capacity developers. Facilitators, implementers of policies and programs. Finally, recommends policy implication for an effective agricultural extension system in Malaysia.*

Keywords: *Adaptation, climate change impact, oil palm, smallholders*

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I. Introduction

Climate change is among the most stunning confront faced by the global world which poses its negative impact in many ways. It is defined as the change in climate over long period of time, whether due to natural variability or as a product of human action and it is now considered as the most significant threat to the world (Sterrett, 2011). The most prominent carbon producer nations from forests cover loss are (1) Latin America and the Caribbean (Brazil: 340 TG c/year), (2) Sub Sarah Africa (Democratic Republic of Congo: 23 TG c/year) (3) South and South-East Asia were (Indonesia and Malaysia 105: TG c/year). Malaysia was third most astounding at 41 Tg c/year (Oram et al., 2017). Right now, Malaysia, with a populace of around 27 million, is the 26th leading ozone-depleting substance producer on planet. It might climb the rundown rapidly because of the development rate of emissions in the country. Because of high ozone depleting substance outflows, the temperature is anticipated to ascend by 0.3– 4.5°C. Hotter temperature will cause ocean level to rise by around 95 cm over a hundred-year time frame. The alterations in precipitation may vary from about −30 to +30%.

The projection demonstrates greatest month to month precipitation will rise up to 51% in some states such as Pahang, Kelantan, and Terengganu, and the least possiblerains will reduce by 32– 61% for whole Peninsular Malaysia. Thus, yearly precipitation will rise by 10% in Kelantan, Terengganu, Pahang and North-West Coast and decreased by 5% in Selangor and Johor (Zubaidi, 2010). This variation of climatic factors will make the agricultural structure be susceptible in Malaysia.Climate change had turn out to be a hot environment subject in the preceding years, since climate change extensively alleged as intimidating to the existing of farmers in Malaysia. There are many journals supported the evidence related the impact of climate change on the increase of air temperature, the rise of sea level, and changes on rainfall. Climate is one of the essential factor deciding the growth and oil palm efficiency notwithstanding a few agricultural based practices, for example, land clearing, harvesting, and fertilizer/manure application are affected by climatic scenario.The key climate parameters are temperature, precipitation, drought, water shortage, and daylight periods per day (Corley, Rao, Palat, & Praiwan, 2017), in which precipitation most of the time end up as constraining component for oil palm growth and development. Oil palm develops well in a region having annual precipitation at 1,750 – 3,000 mm appropriated uniformly and consistently. Least precipitation for oil palm development is 1,250 mm with no dry month. Climate change will specifically influence oil palm productivity. Oil palm plantation requires even distribution of rainfall consistently, in this manner there is a forecast that climate change will adversely affect oil palm yield (Clements, Suon, Wilkie, & Milner-Gulland, 2014). Adaptation is important action in climate change response (Murniningtyas et al., 2015).

Even though, there is a full-fledged Department of Agriculture (DOA), well trained man-power in Malaysia and physical infrastructure, the in the country. Malaysia Agriculture Research and Development Institute (MARDI) was established for providing technological backing for agricultural development of the country, but its role has also been redefined in line with the global and national developments to be able to accommodate climate change related hazards faced by the farmers. With the help and guidance of extension services, farmers become capable to adopt and attain self-sufficiency.In this context,to meet the challenges of the smallholder oil palm farmers on climate impact, there is need to review the activity based adaptation strategies and the role of agricultural extension towards activity-based adaptation strategies in Malaysia. However, torecommends ways on how to improve on theeffectiveness of agricultural extension servicesinthis context.

II. Reduce Oil Palm Productivity

Climate change causes higher precipitation fluctuation and less reliable precipitation because of expanded dry periods and an extraordinary precipitation (Mengel, Nauels, Rogelj, & Schleussner, 2018). Both dry season periods and high precipitation will negatively influence oil palm efficiency as perceived by (Murtilaksono et al., 2011). The regular impacts of dry influence pressure are (i) increase of abortion; (ii) Rotten bunch; (iii) low productivity; and (iv) Elongated inflorescences (8-9 months). (Murtilaksono et al., 2011) demonstrated that drought or water deficiency expanded lance leaf number and frond break and superficially decrease oil palm production.

The dry condition causes the oil palm unfit to take enough water for modification of cell respectability, diminishing supplement take-up, and plant absorption activities, in which the photosynthesis actions at dry period around 60 % from photosynthesis events at rainy season (Murtilaksono et al., 2011).The drier situation will restrain the oil palm development since oil palm metabolism and inflorescences forms were aggravated which for the most part called “drought stress”. A high mean annual temperature that falls within the recognized weather sceneries required for the thriving of oil palm is favourable for higher fruit production (Goff & Salomone, 2015). Nevertheless, if such rise in temperatures will lead to drought conditions, it is expected that about 208,000 ha of land or 12% of the existingpart would be termed as either marginal or inappropriate for oil palm (Zainal, Shamsudin, Mohamed, & Adam, 2012). Absence of water can cause declined of female and male flowerproduction (Verheye, 2012).

2.1 Pest and Disease Outbreak

The huge effect on pests and diseases perspective was the changing of their status (Clements et al., 2014; Siwar, Alam, Murad, & Al-, 2012). Changes of earlier insignificant pests turn out to be significant pests frequently happen in several circumstances. Temperature rise, for instance, has caused the changes on life cycle, productiveness and distribution of insect pests and also destroying the common enemies (Aak, Hage, & Rukke, 2018).Ganoderma, a soil borne fungus, is agrowingworry for those farmers who operate oil palm plantations in Malaysia as it causes infection to oil palm trees. Ganoderma is a wood-decaying fungus which can affect different types of trees, including oil palm.

A disease called basal stem rot (BSR) is a major disease that was recorded on oil palm planted in shoreline of Peninsular Malaysia(Fadzil et al., 2017; Ming, Fah, & Ahmad, 2016). The basal stem rot (BSR) can be infected through Ganoderma. An intense fall of the production of FFB is re-counted when infested by this fungus along with wilting or dehydration of leaves of palm trees. Ganoderma is proficient of causing substantial yield damages that pave the wayto the actual loss of a palm tree, while transmutably spread through some of the element of climate, wind and water in increasing areas of a plantation can be caused by spores discharged from mushroom bodies.

Oil palm planted on beach front marine clays is defenseless to this disease due to high amount of water. In any case, the disease likewise happens on peat and inland soils that is categorized by high water content. Excessive rainfall also increase damage of fruit bunch, especially on plantation developed in higher altitude (> 600 m asl). Cultivation at higher altitudes and/or lower and higher latitudes may be possible beyond the lowland tropics as climate change progresses (Paterson &Lima, 2017). Severe damage of fresh fruit bunches caused by Marasmius palmivorus often found in several plantations in Indonesia and Malaysia.

2.2Reduce Soil Fertility and Infrastructure

The excessive rainfall at rainy season produces high surface runoff as occurs in some Malaysian states. The runoff influences high water loss and incites soil degeneration that discards top soil with a high substance of organic matter supplements, soils end up unproductive particularly difficult soil physical properties (Pimentel & Burgess, 2013). The impact of outrageous precipitation on oil palm growth and productivity is not as more regrettable as the effect of drought. An extraordinary precipitation tends to influence the plantation structure, harvest activity, and flooding. A rainy condition is largely followed by rise in fruit production due to moderately quick maturing of oil palm product. Extraordinary precipitation generally lessen road quality and hinders harvest movement in the plantation. On hilly topography, extreme precipitation prompt high erosion and landslide, however in regions that near to the stream there is a likelihood of flooding. 190,600ha of oil palm smallholdings across the nation and major plantation players, have been affected by the floods. However, 7,500 smallholders covering an area of 24,000 ha in seven states to be specific Selangor, Johor, Pahang, Terengganu, Kelantan, Perak, and Sabah have been affected by the floods (Banna et al., 2016).

III. Activity-based Adaptation Strategies

Adaptation is the adjustments of normal or human system in response to actual or anticipated stimuli, or its effects to moderate the harm or exploit beneficial opportunities (IPCC, 2014). In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities(IPCC: WGII AR5, 2014). Thus, the term adaptation used in climate change realm to mean adjustments in a natural system's behaviour and characteristics that enhance the ability to cope with external stresses (flood, Tornado, drought, Cyclone, tsunami, etc.). It has suitably been defined by the European Commission as: “Adaptation means anticipating the hostile effects of climate change and taking suitable action to avert or minimize the damage they can cause, or taking advantage of opportunities that may arise.”(Murtilaksono et al., 2011; Sutarta, Santoso, & M. A., 2015). However, in this context activity-based adaptation strategies refers to as a process of applying the good agricultural management practices to adapt to actual or expected climate impact.Activity based adaptation strategies comprises of existing management practices involved in palm oil agronomy: (a) finding planting material tolerant to climate change, (b) increasing water saving and infiltration, (c) decreasing evapotranspiration, and (d) monitoring emerging pest and diseases. In addition, diffusion of those strategies to the oil palm growers is very important as well as the role of extension services must to be addressed. Activity based practices can avert or lessen damages in some farm land(Dislich et al., 2017).

3.1The Use of Resistant Varieties

The choice of oil palm cultivars with tolerance to biotic and abiotic pressures like flooding, drought, high temperature, pest, and disease resistance allows utilizing genetic variability in new crop varieties(Barcelos et al., 2015). Changing climatic circumstances might also make plants more susceptible to pest and disease. Along these lines, the breeding program to deliver high tolerant planting material to diseases and pest is additionally required next to produce high tolerant planting material to climatic impact (Rival, 2017).Breeding oil palm for climate change necessitates multidisciplinary and collective research.The exploitation of germplasm material is beginning to bear its rewards and shows a lot more genetic diversity. Meanwhile, parental lines of advanced breeding materials are continuously being improved through extensive breeding programmes. Coupled with improving breeding and mass propagation methods to increase yield. Stimulating developmental research to produce resistance planting materials to most important pests and diseases such as Ganoderma, and developed palm architecture will also have substantial impact to the improvement of new oil palm assortments in the coming decades. Moreover, there is likewise an expanding interest to hasten oil palm breeding for better adaptation to dry spell, warm, and other abiotic stresses (Zulkifli et al., 2017).

Oil palm germplasm that displays economically imperativequalities is a valuable resource for oil palm development. Identifying this, E. guineensis germplasm was collected from Africa to expand the genetic base of oil palm breeding materials in Malaysia at that time. Far-reaching screenings should be constantlysupported for those materials collected in order to exploit their genetic potential in oil palm breeding programmes. Population diversity studies among MPOB oil palm germplasm collection are very vital for a basis set of germplasm with minimal repetitive and maximal genetic diversity (Zulkifli et al., 2017).

A study by (Arolu et al., 2016) reported that MPOB germplasm materials pull together from Nigeria, Cameroon, Senegal, Tanzania, Angola and Madagascar had experienced extreme low rain. Palms from these varieties are possibly useful for the improvement of heat and drought tolerant planting materials. Oil palms from Tanzania are identified for thin-shelled tenera (PS5) and great bunch index (PS7)(Din, 2017). In recent times,(Zulkifli et al., 2017)testified that Nigeria, Tanzania, Angola, and Cameroon germplasms hasgreat bunch index (BI) which is avital trait selection towards increasing yields and high adaptability to dry season and cold condition.

3.2Soil and Water Conservation

Take out the soil erosion, nutrients and water shortfalls of oil palm plantations through agricultural practices for example soil and water conservation practices and mulching can rise the oil palm productivitydirectly through increasing the bunch weight and oil content of fruits (Moradi, Teh Boon Sung, Goh, Husni Mohd Hanif, & Fauziah Ishak, 2015). Utilization of soil and water conservation practices such as (terrace and silt pits) and mulches (pruned oil palm fronds, empty fruit bunches, and Eco-mat) are the utmost well-known techniques of oil palm yield strengthening which have been practiced for a number ofyears in Malaysia.

In spite of the high yearly precipitation in the tropics, intermittent water stress still happens in oil palm plantations because of uneven precipitation dispersion and high atmospheric evaporation demand on the crop due to high air temperatures (Murtilaksono et al., 2011). The utilization of irrigation system has demonstrated little assurance because of its high establishment and support costs (Murtilaksono et al., 2011). Accordingly, legitimate soil and water preservation practices are expected to boost or conserve soil water, in this way, bringing down the danger of water stress and furthermore to decrease soil erosion and maintain soil productivity.

(1)Terraces are built with the drive of reducing run-off and soil erosion across the hill slopes (Troeh et al., 2004). Notwithstanding significant impact of terracing to decrease run-off and erosion on gentler slopes, terracing loses its effectiveness and should to be exchanged by other management practices (Corley and Thinker, 2003). In spite of theadvantages of terracing, soil compaction and removing of a fertile layer of topsoil in the course of construction of terraces reduce soil productivity (Hamdan, Man, & Shaffril, 2017). Negative impacts of terracing on soil have constrained some oil palm plantations to utilize mulches and silt pits on non-terraced slopes.

(2)Silt pit is one of the much-admired soil-water conservation methods in Malaysian oil palm plantation(Bohluli, Sung, Hanif, & Rahman, 2014). It functions by decreasing soil erosion, checking run-off and sedimentation, increasing oil palm yield through providing more water, particularly during dry conditions, protecting and increasing soil fertility through decrease of nutrient loss and redistribution of dissolved nutrients into the soil. Silt pit redistributes collected water and nutrients into the oil palm root zone rather than being lost through profound permeation (Bohluli, Sung, Hanif, & Rahman, 2015; Murtilaksono et al., 2011).

Additionally studied the adequacy of ridge terraces and silt pits on soil moisture content on oil palm plantations. Results demonstrated that the soil water content was elevated in silt pit treatment, monitored by ridge terrace and control. The planted oil palms in control displayed earlier water insufficiency compared with other treatments. Soil moisture content point out that silt pit was able to keep the soil water content for a longer time compared with 5 different treatments. They presumed that silt pit influences higher and steadier soil water moisture content related with ridge terrace and control, so that, the oil palm’s water demand would be fulfilled better and the production would increase significantly.

3.3 Organic Mulching

Organic mulching is one viable and built up approach to conserve soil and water. Application of oil palm remains such as pruned oil palm fronds (OPF) and empty fruit bunches (EFB) as a mulches is a typical management practice in oil palm plantations particularly on non-terraced slopes(Samedani et al., 2014). The regard of using oil palm remains as mulch is because oil palm produces hugevolume of biomass that have to be recycled to avoid large amounts of wastes. 96% of oil palm's entireyearly dry matter production is stored in its above ground biomass (trunk, fronds, and bunches). In 2012, for example, Malaysia's palm oil industry produced 43 million tons of biomass (Samedani et al., 2014).

3.4 Weed and Cover Crop Management

The species arrangement of weed populations in oil palm areas differs according to climate, the environmental conditions, and husbandry methods (Samedani et al., 2014). Irrespective of the arrangement, weeds compete with oil palm for nutrients, particularly during setting up and early growth stages, upsetting its growth and yield and hindering routine plantation practices (Abdurahman, Rosli, & Azhari, 2011). Though herbicide application is the most cost effective and commonly used weed control technique(Barcelos et al., 2015), its use is becoming graduallynot accepted with the farmers(Farooq, Hussain, Wahid, & Siddique, 2012). Replacement of soft weeds by noxious weeds, do away with habitat for predators of insect pests, eliminate useful insects, contaminate natural resources and weed resistance are the reasons to make herbicide use not accepted in commercial agriculture (Aak et al., 2018). Oil palm is ever more under world scrutiny with prominence on viable cultivation. Cultivation of cover crops qualifies as part of a viable agricultural practice. Leguminous cover crops are used as an intercrop, to cohabit with the oil palm following plantation clearing and planting or replanting, to make availableample cover to an otherwise bare soil to protect the soil from the impact of erosion. The leguminous cover crops also carry out multiple functions such as decreasing soil water evaporation, runoff losses, and soil erosion, improve or maintain soil fertility and recycling of nutrients (Samedani et al., 2015). The frequently used leguminous cover crops species in Malaysia are Pueraria phaseloides (synonym for Pueraria javanica), Centrosema pubescens, Calopogonium mucunoides, C. caeruleum and of late Mucuna bracteata (Samedani et al., 2015).

3.5 Agronomic Practices

Agronomic practices to reduce evapotranspiration before dry season. Practices such as: (i) flower castration, (ii) fertilizer application especially potassium, (iii) frond management to maintain average quantity of fronds (48 – 56 fronds for < 8 year oil palm, and 40 – 48 fronds for ≥ 8 year oil palm. Trimmed frond can be prepared steadily in the plantation to lessen evaporation (Murtilaksono et al., 2011). Decreasing nitrogen fertilizer drops nitrogen-based emissions. Oil palm plantations discharge huge amounts of nitrous oxide (N2O) into the atmosphere connected to nitrogen (N) fertilizer used (Dislich et al., 2017).

IV. Role of Extension Services

Agricultural extension can be defined as an ongoing process of getting useful information to farmers and assisting them to acquire the knowledge, skills and attitudes to use effectively the information and technology to increase productivity (Shah, Asmuni, & Ismail, 2013). This definition gives to an agricultural extension the command to oblige the issue of climate change in its obligations. The effectiveness of extension services is also highly dependent on the ability of extension agents who are qualified, knowing their roles and competent as the whole extension process is dependent on them to transfer information to farmers (Lauzon, 2013). In any case, with a specific results, there is the need for change in roles and ability in the extension system so as to accommodate the new scopes conveyed about by adaptation to climate impact(Berry et al., 2010).

4.1 Technologies and of Information Management

Malaysia Agriculture Research and Development Institute (MARDI) was established for providing technological support for agricultural advancement of the country. Extension traditionally has assumed a role in providing sufficient material and encouraging new inventions or methods for dealing with crops and farms (Baloch & Thapa, 2016). Extension also relate farmers to researchers and other players in the innovation system (Hassen, Sokora, & Taha, 2016). Farmers, extension agents, and researchers must work hand in hand on farmers' fields to prioritize, test, and encourage new crop varieties and management systems (Davis & Terblanché, 2016). While extension needs to go outside such a procedures, there is still a need for straightforward technology transfer on adaptation strategies to climate impact(Kendra & Kendra, 2013). MARDI needs to fulfill its role effectively as the developer of new technology for the Malaysian oil palm growers, indeed more effective extension is urgently needed to promote existing proven technology(Leeuwis, 2014).Today's farmers will need to be able to hastily respond to climate change and expertly manage risk. Farmers need to devise access to this kind of information be it climatic evidence, forecasts, adaptive technology, innovations through extension and information systems(Ayers & Forsyth, 2014).

4.2 Capacity Development

There is a need for the deployment of agricultural extension services to achieve a variety of rural development goals, and part of this is to allow farmers to understand, and adapt to new climate change challenges (Ozor& Cynthia, 2015). Another extension's major activities over time have been adult and non-formal education(UNESCO, 2016). This role continues till today and is even more important in light of adapting to the climate impact. The capacity of farmers to deal with various climatic impact will turn out to be perpetually fundamental, and extension struggles must give careful consideration to teaching farmers about their choices to improve adaptation strategies(IPCC, 2007). Education must thus move outside technical training to enhance farmers' capabilities for planning, prioritizing, problem solving, critical thinking, negotiating, leadership skills and building consensus working with multiple stakeholders, finally, being proactive (Berthe, 2015). To enhance brings about country improvement, farmers and extension managers require new skills that will necessitate agricultural education and extension programmes to incorporate esteeming understanding the information and understandings of rural people and co-learning (That is, farmers and extension agents learning together instead of extension agents training farmers in a one-way knowledge transfer).

4.3 Policy and ProgramsImplementations

Develop and implement policies to ensure proper utilization of the resources, water, land, infrastructure, time to time in the light of changing climate conditions. Additional role of extension, which will be thoughtful for climate change adaptation, is that of uniting together different actors within the rural sector. Ordinarily, this has implied relating farmers to transport operators, markets, and inputs suppliers, among others (Enete & Onyekuru, 2011). With climate change, it will be progressively important for the extension system to connect farmers and other individuals in rural communities specifically with private and public institutions that propagate adaptation technologies, and sponsoring programs adaptation investments. Extension additionally has a colossal test in uniting farmers' worries and those of other actors as they address both climatic and market uncertainties together. (Ozor, & Cynthia, 2015). Extension has the opportunity to make a substantial impact to overcoming this gap through better farmer decision making(Davis & Terblanché, 2016).Extension agents might similarly play a role in supporting farmers in implementation of policies and programs that connect farmers with governmental, and non-governmental organizations at the national and international levels that deals with climate related issues (Yusa et al., 2015).

V. Conclusions

The Malaysian oil palm industry has substantial impact on the national economy, particularly on the agricultural sector, and it is the 4th largest contributor to the national economy. Around 60 % of international trade in vegetable oils yet expected 74 % of global palm oil usage is for food products and 24 % is for industrial drives. Moreover, climate change had influenced the oil palm growth and productivity as the crop remains prone to threat by a variety of factors both biotic and abiotic in Malaysia. Adaptation strategy is applied to reduce impact of climate change on oil palm, includes finding new variety tolerant to extreme condition, applying appropriate agronomic practices to reduce water losses and oil palm losses. It is imperative that the role of extension services would be able to guide the farmers in numerous ways to be able to adapt to climatic impacts in oil palm plantations. Under oil palm production, the focused events are field preparation, selection of planting materials, weed and pest controls, and fertilizer applicationwhich serve as a guide-post for extension activities.The frequent increase of climate change will place Malaysia at higher risks of facing the impacts of climate change. Strategic responses to build up Malaysia’s adaptation capability to climate impact is addressed through effective extension services.

5.1 Recommendations

This are with regard to extension service delivery in improving the activity-based strategies among smallholder farmer in Malaysia.Moreover,when the smallholder farmers have access to good extension service delivery they will definitely expand their production which will be translated to more job creation, increase income, reduce poverty, and discourages rural-urban migration. Therefore, the following recommendation were made;

(1)Support knowledge-based practices. Good Agricultural Practice (GAP) as a standard guideline in implementing activities of technology transfer in the extension program must be maintained in all oil palm cultivation practices, from field preparation, selection of planting materials, weed and pest controls, and fertilizer application in Malaysia.

(2) The Malaysian government need to expand and strengthen agricultural extension at the State level to Increase awareness and farmers participation to promote behavioural responses to climate change and facilitate the transfer of research findings and requirements to and from the farmers.

(3)Harmonize the existing policies to addresses climate change adaptation strategies and extension services in a balanced manner to improve collaboration through efficient communication and coordination among all stakeholders for effective implementation of climate change adaptation strategies.

(4)Planning and executing extension programs must get continuous support from various parties including all the stake-holders in oil palm production.Malaysia Agriculture Research and Development Institute (MARDI) needs to fulfill its role effectively as the developer of new technology for the Malaysian oil palm growers,indeed more effective extension is urgently needed to promote existing proven technology.

References

[1]. Aak, A., Hage, M., & Rukke, B. A. (2018). Insect pathogenic fungi and bed bugs: behaviour, horizontal transfer and the potential contribution to IPM solutions. *Journal of Pest Science*, *91*(2), Pp 823–835. https://doi.org/10.1007/s10340-017-0943-z

[2]. Abdurahman, N. H., Rosli, Y. M., & Azhari, N. H. (2011). Development of a membrane anaerobic system (MAS) for palm oil mill effluent (POME) treatment. *Desalination*, *266*(1–3), Pp 208–212. https://doi.org/10.1016/j.desal.2010.08.028

[3]. Arolu, I. W., Rafii, M. Y., Marjuni, M., Hanafi, M. M., Sulaiman, Z., Rahim, H. A., Nookiah, R. (2016). Genetic variability analysis and selection of pisifera palms for commercial production of high yielding and dwarf oil palm planting materials. *Industrial Crops and Products*, *90*, Pp 135–141.

[4]. Ayers, J., & Forsyth, T. (2014). Community based adaptation to climate change. https://doi.org/10.3200/ENV.51.4.Pp 22-31

[5]. Baloch, M. A., & Thapa, G. B. (2016). The effect of agricultural extension services: Date farmers’ case in Balochistan, Pakistan. *Journal of the Saudi Society of Agricultural Sciences*. https://doi.org/10.1016/j.jssas.2016.05.007

[6]. Banna, H., Afroz, R., Masud, M. M., Rana, M. S., Koh, E. H. Y., & Ahmad, R. (2016). Financing an efficient adaptation programme to climate change: A contingent valuation method tested in Malaysia. *Cahiers Agricultures*, *25*(2). https://doi.org/10.1051/cagri/2016014

[7]. Barcelos, E., Rios, S. de A., Cunha, R. N. V., Lopes, R., Motoike, S. Y., Babiychuk, E., Kushnir, S. (2015). Oil palm natural diversity and the potential for yield improvement. *Frontiers in Plant Science*, *6*(March), Pp 1–16. https://doi.org/10.3389/fpls.2015.00190

[8]. Berry, N. J., Phillips, O. L., Lewis, S. L., Hill, J. K., Edwards, D. P., & Tawatao, N. B. (2010). The high value of logged tropical

forests : lessons from northern Borneo, Pp 985–997. https://doi.org/10.1007/s10531-010-9779-z

[9]. Berthe, A. (2015). Extension and Advisory Services Rural Extension Services for Agricultural Transformation. *Background Technical Paper*, 1–30.

[10]. Bohluli, M., Sung, C. T. B., Hanif, A. H. M., & Rahman, Z. A. (2014). Silt pit efficiency in conserving soil water as simulated by HYDRUS 2D model. *Pertanika Journal of Tropical Agricultural Science*, *37*(3), Pp 321–330.

[11]. Bohluli, M., Sung, C. T. B., Hanif, A. H. M., & Rahman, Z. A. (2015). Review on the use of silt pits (contour trenches) as asoil and water conservation. *Journal of Chemical Information and Modeling*, *53*(9), Pp 1689–1699. https://doi.org/10.1017/CBO9781107415324.004

[12]. Clements, T., Suon, S., Wilkie, D. S., & Milner-Gulland, E. J. (2014). Impacts of Protected Areas on Local Livelihoods in Cambodia. *World Development*, *64*(S1), S12–S134. https://doi.org/10.1016/j.worlddev.2014.03.008

[13]. Corley, R. H., Rao, V., Palat, T., & Praiwan, T. (2017). Breeding for Drought Tolerance in Oil Palm. *Journal of Oil Palm Research*, *30*(March), Pp 26–35. https://doi.org/10.21894/jopr.2017.00011

[14]. Davis, K. E., & Terblanché, S. E. (2016). Challenges facing the agricultural extension landscape in South Africa. *South African Journal of Agriculture Extension*, *44*(2), Pp 231–247. https://doi.org/http://dx.doi.org/10.17159/2413-3221/2016/v44n2a428

[15]. Din, A. K. (2017). Malaysian Oil Palm Industry Performance 2016 and Prospects for 2017. Retrieved from http://www.mpob.gov.my/images/stories/pdf/2017/2017

[16]. Dislich, C., Keyel, A. C., Salecker, J., Kisel, Y., Meyer, K. M., Auliya, M., … Wiegand, K. (2017). A review of the ecosystem functions in oil palm plantations, using forests as a reference system. *Biological Reviews*, *92*(3), Pp 1539–1569. https://doi.org/10.1111/brv.12295

[17]. Enete, A. A., & Onyekuru, A. N. (2011). challenges of Agricultural Adaptation to climate change: Empirical Evidence from Southeast Nigeria. *Tropicultura*, *29*(4), Pp 243–249. https://doi.org/10.1108/IJCCSM-08-2012-0045

[18]. Fadzil, F. B., Idris, K., Samah, B. A., Samah, A. A., Azril, H., & Shaffril, M. (2017). Examining Highland Youth Farmers ' Adaptation Ability towards Climate Change Impacts, *7*(4), Pp 527–537. https://doi.org/10.6007/IJARBSS/v7-i4/2826

[19]. Farooq, M., Hussain, M., Wahid, A., & Siddique, K. H. M. (2012). *Plant Responses to Drought Stress*. https://doi.org/10.1007/978-3-642-32653-0

[20]. Hamdan, M. E., Man, N., & Shaffril, M. (2017). Farmers ' Adaptive Capacity towards the Impacts of Global Warming : A Review, *9*(13). https://doi.org/10.5539/ass.v9n13p177

[21]. Hassen, J. Y., Sokora, A., & Taha, M. (2016). Identifying Pathways Linking Agricultural Education , Training and Extension, (August).

[22]. IPCC. (2007). Climate change 2007 : impacts, adaptation and vulnerability : Working Group II contribution to the Fourth Assessment Report of the IPCC Intergovernmental Panel on Climate Change. (July), 976. https://doi.org/10.2134/jeq2008.0015br

[23]. IPCC. (2014). Summary for Policymakers. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://doi.org/10.1017/CBO9781107415324

[24]. Kendra, K. V., & Kendra, K. V. (2013). Role of extension agencies in climate change related adaptation strategies. *International Journal of Farm Science*, *3*(1), Pp 144–155.

[25]. Lauzon, A. (2013). From agricultural extension to capacity development: Exploring the foundations of an emergent form of practice. *International Journal of Lifelong Education*, *32*(2),Pp 247–266. https://doi.org/10.1080/02601370.2012.736087

[26]. Leeuwis, C. (2014). Communication for Rural Development, 321. Retrieved from http://www.fao.org/3/a-i3492e.pdf

[27]. Mengel, M., Nauels, A., Rogelj, J., & Schleussner, C. F. (2018). Committed sea-level rise under the Paris Agreement and the legacy of delayed mitigation action. *Nature Communications*, *9*(1), Pp 1–10. https://doi.org/10.1038/s41467-018-02985-8

[28]. Ming, S. C., Fah, J. B. C., & Ahmad, K. (2016). Field ablation as cultural control for bunch moth Tirathaba mundella infestation in young mature oil palm. *Journal of Oil Palm Research*, *28*(4), 463–470.

[29]. Moradi, A., Teh Boon Sung, C., Goh, K. J., Husni Mohd Hanif, A., & Fauziah Ishak, C. (2015). Effect of four soil and water conservation practices on soil physical processes in a non-terraced oil palm plantation. *Soil and Tillage Research*, *145*, Pp 62–71.

[30]. Murniningtyas Endah. (2015). Indonesia Food Security Presentation. Retrieved July 18, 2018, from https://www.researchgate.net/publication/276920122. Indonesia Food Security Presentation

[31]. Murtilaksono, K., Darmosarkoro, W., Sutarta, E. S., Siregar, H. H., Hidayat, Y., & Yususf, M. A. (2011). Feasibility of soil and water conservation techniques on oil palm plantation. *AGRIVITA, Journal of Agricultural Science*, *33*(1), Pp 63–70.

[32]. Oettli, P., Behera, S. K., & Yamagata, T. (2018). Climate Based Predictability of Oil Palm Tree Yield in Malaysia. *Scientific Reports*, *8*(1),Pp 1–13. https://doi.org/10.1038/418-018-20298-0

[33]. Oram, D. E., Ashfold, M. J., Laube, J. C., Gooch, L. J., Humphrey, S., Sturges, W. T., … Sherry, D. (2017). A growing threat to the ozone layer from short-lived anthropogenic chlorocarbons. *Atmospheric Chemistry and Physics*, *17*(19), Pp 11929–11941.

[34]. Ozor, N., & Cynthia, N. (2015). The role of extension in agricultural adaptation to climate change in Enugu State , Nigeria (April), Pp 41–50.

[35]. Paterson, R. R. M., & Lima, N. (2017). Climate change affecting oil palm agronomy, and oil palm cultivation increasing climate change, require amelioration. *Ecology and Evolution*, (September 2017), Pp 452–461.

[36]. Pimentel, D., & Burgess, M. (2013). Soil Erosion Threatens Food Production. *Agriculture*, *3*(3), Pp 443–463. https://doi.org/10.3390/agriculture3030443

[37]. Rival, A. (2017). Breeding the oil palm (*Elaeis guineensis* Jacq.) for climate change. *Ocl*, *24*(1), D107. https://doi.org/10.1051/ocl/2017001

[38]. Samedani, B., Juraimi, A. S., Abdullah, S. A. S., Rafii, M. Y., Rahim, A. A., & Anwar, M. P. (2014). Effect of cover crops on weed community and oil palm yield. *International Journal of Agriculture and Biology*, *16*(1), Pp 23–31.

[39]. Samedani, Juraimi, A. S., Rafii, M. Y., Awadz, S. A. S., Anwar, M. P., & Anuar, A. R. (2015). Effect of Cover Crops on Weed Suppression in Oil Palm Plantation. *Internatinal Journal of Agriculture & Biology*, *17*(2010), Pp 251–260.

[40]. Shah, J. A., Asmuni, A., & Ismail, A. (2013). Roles of Extension Agents Towards Agricultural Practice in Malaysia, *3*(1), Pp 59–63.

[41]. Siwar, C., Alam, M., Murad, W., & Al-, A. Q. (2012). Impacts of Climate Change on Agricultural Sustainability and Poverty in Malaysia, Pp 1–15.

[42]. Sterrett, C. (2011). Review of Climate Change Adaptation Practices in South Asia. *Change*, (November), Pp 1–100. Retrieved from http://www.oxfam.org/sites/www.oxfam.org/files/rr-climate-change-adaptation-south-asia-161111-en.pdf

[43]. Sutarta, E. S., Santoso, H., & M. A., Y. (2015). Climate change on oil palm : is 's impacts and adaptation strategies. *Researchgate*, (April). Retrieved from https://www.researchgate.net/publication/265201096

[44]. UNESCO. (2016). Formal and non-formal adult education opportunities for literacy and numeracy, and other skills ffor acquisition and retention: A 29-country review of the concepts, processes and structures of literacy provision and reporting, Pp 58.

[45]. Yusa, A., Berry, P., Cheng, J. J., Ogden, N., Bonsal, B., Stewart, R., & Waldick, R. (2015). Climate change, drought and human health in Canada. *International Journal of Environmental Research and Public Health*, *12*(7), Pp 8359–8412.
[46]. Zainal, Z., Shamsudin, M. N., Mohamed, Z. A., & Adam, S. U. (2012). Economic Imapct of Climate Change on the Malaysian Palm Oil Production. *Trends in Applied Sciences Research*. https://doi.org/10.3923/tasr.2012.872.880
[47]. Zubaidi, J. (2010). Climate Change:Potential Impacts On Water Resources And Adaptation Strategies In Malaysia. *Climate Change Impacts To The Water Environment And Adaptation Options*.
[48]. Zulkifli, Y., Norziha, A., Naqiuddin, M. H., Fadila, A. M., Nor Azwani, A. B., Suzana, M., … Kushairi, A. (2017). Designing the oil palm of the future. *Journal of Oil Palm Research*, *29*(4), Pp 440–455. https://doi.org/10.21894/jopr.2017.00015

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