**CLIMATE SMART AGRICULTURE AND SMALL HOLDER FARMERS**

**Mohamed Naseef k**

**Research Scholar in Development Studies**

**Thunchathezhuthachan Malayalam University, Kerala**

**naseefkt26@gmail.com**

**9895247773**

**ABSTRACT:**

Climate change is one of the major threats faced by humanity in the present world. Climate change is negatively affecting various fields of human life and agriculture is the main sector affected by climate change. Since the crop productivity depends on the climate variances, continuous climate change lowers the productivity which would in turn affect the income and livelihood of farmers. Agriculture is already facing the issue of providing food to a growing population. Climate changes, along with it would harm the food security. Climate resiliency is the need of the hour and adoption of climate smart agriculture is the convenient method of climate resilient farming. To be climate change resilient, climate smart farming should be adopted by farmers in large number. One or two isolated adoption of climate smart farming will not do the job. Hence the adoption of climate resilient farming in large scale should be encouraged. The present study analyses the use and impact of climate resilient farming along with the scope of small farmers in adopting the same.

**Key Terms:** Climate change**,** Climate Resiliency, Climate Smart Agriculture, Farming Practices, Small farmers

**INTRODUCTION**

Climate change poses significant threats to both the abiotic (physical) and biotic (living) parts of the environment as well as economic growth and social well-being – especially in less developed countries. Climate change impacts the agricultural sector in various ways, like increased variability with respect to temperature and rain, intensity and frequency of extreme weather events and perturbations in ecosystems. These could cause an increased variability of production, decrease of production in certain areas as well as the changes in the geography of production. The only way to cope up with the challenges posed by climate change is by building resilience for adaptation in the agriculture sector. The globally alarming news on climate change as well as its impact on agriculture demands a change in the farming practices. The Intergovernmental Panel on Climate Change (IPCC) has defined resilience as: "the ability of human communities to anticipate, absorb, accommodate and recover from the effects of disturbances" (IPCC,2012). Resilience Assessments have emerged as a key method of understanding human responses to disasters and help them to prepare better strategies to reduce the subsequent negative effects, thus empowering a community that can withstand and adapt to various future disasters (Burton,2015). Thus, the resilient communities are capable for either avoiding or minimizing the negative impacts of climate disasters. Climate change is a threat to food security systems and one of biggest challenges in the 21st century (FAO, 2013). It is widely accepted that the ability to contain the pace of climate change by keeping change in temperature rise within 2°C threshold in the long run is now limited and the global population will have to deal with its consequences (IPCC, 2014). Agricultural production systems are expected to produce food for the global population that is expected to reach 9.1 billion people in 2050 and over 10 billion by end of the century (World Bank, 2011).

The concept of Climate Smart Agriculture is getting considerable attention in the international level as it helps in agricultural planning under climate change. Climate-Smart Agriculture (CSA) is an approach to agricultural development that aims to address the intertwined challenges of food security and climate change (Lipper et al., 2014). CSA targets three objectives:

1. sustainably increasing agricultural productivity to support equitable increases in farm incomes, food security, and development;
2. adapting and building resilience of food systems to climate change; and
3. , where possible, reducing greenhouse (GHG) emissions from agriculture (FAO,2013). Whether a technology is CSA is based on its impact on these outcomes and agricultural interventions that meet these goals are considered “climate-smart” (FAO,2013).

Interventions ranging from climate information services to field management have potential to achieve these goals (Faures et al., 2013; Khatri-Chhetri et al., 2016;Nyasimi et al., 2017). Climate change is a major threat to the global food security. Agricultural sector is already facing a challenge by meeting food demand for a growing population which is exacerbated by climate change. In this frame, the concept of Climate Smart Agriculture is very relevant. This concept was introduced by FAO in 2010. The climate change debate started in the early 1980s with the publication of the Brundtland report in 1987.Global humanity has endeavoured to respond to climate change through adjustments in ecological-social-economic systems to actual or expected climatic stimuli, their effects or impacts (IPCC, 2001;Smit & Olga, 2001).

**Climate Smart Agriculture:**

The concept of climate-smart agriculture (CSA) was introduced in 2010 by the Food and Agriculture Organization (FAO) of the United Nations to face climate change in the agricultural sector (FAO, 2010). It is an integrated approach to farming to address the problems of climate change in the farming system (Ramamasy & Baas, 2007). It can help improve crop yields for enhancing food security by using environmentally friendly techniques (FAO, 2010; World Bank, 2011; Ho & Shimada, 2019). Transformation in agricultural systems is crucial and urgent to be implemented in areas that mainly rely on rainfed agriculture and face the changing climate (Belay et al, 2017). The conservation of agricultural system avoids further destruction of soil structure, improves the organic content in the soil and retains more water to maximize the crop yield, prevent soil erosion and downstream flooding (Olawuyi, 2020). Moreover, these environmental benefits help to strengthen the economic sector to face poverty (FAO, 2010). Agroforestry system is one of the CSA practices that combine agricultural crop production including trees, forestry plants, and animal husbandry in the same unit of land in accordance with the culture of the local population for public welfare (Suryani & Dariah,2012). Planting trees improve the organic matter in the soil. As a result, soil fertility and soil moisture increase as well (FAO, 2010). Moreover, the presence of forests lessens the rate of small to moderate rain flows. The water that falls to the ground is more controlled and doesnot erode the soil (Asdak, 2010).

**Climate Change and Agricultural Production:**

Climate change projections in relation to future rainfall, floods and drought are uncertain (Okumu, 2013). However, temperature projections are generally reliable. General warning of global warming in Sub-Saharan Africa is projected to be larger than the global annual average (IPCC, 2007). As regarding temperature, increased temperature levels will cause additional soil moisture deficits, crop damage and crop diseases; unpredictable and more intense rainfall; and higher frequency and severity of extreme climatic events (Boruru et al., 2011). Similarly, the drivers of climate change have the potential of altering plant growth and harvestable yield through carbon dioxide fertilization effects (UNDP, 2012). Free Air Carbon Enrichment (FACE) experiments indicate productivity increases in a range of 15–25% for crops like (wheat, rice and soya beans) and 5–10% for crops like (maize, sorghum and sugarcane). Higher levels of CO2 also improve water use efficiency of both categories of plants (Lotze et al., 2009).

Climate-smart measures includes proven techniques such as mulching, intercropping, integrated pest and disease management, minimum soil disturbance practices (MSD), crop rotation, agroforestry, integrated crop-livestock management, aquaculture, improved water management, better weather forecasting for farmers and innovative practices, such as early warning systems (FAO, 2010; World Bank, 2011; 2012). It also entails embracing new technologies such as diversifying genetic traits of crops to help farmers edge against an uncertain climate and creating an enabling policy environment for adaptation (World Bank, 2011). In the absence of Climate Smart Agriculture, marginal areas may become less suited for arable farming as a result of land degradation through deforestation, soil erosion, repetitive tillage and overgrazing (World Bank, 2012). However, there is recognition that Climate Smart efforts must have at their heart smallholder farmer in the developing nation who is key to change across the entire agricultural system. Policy accompaniment and financing of the agricultural practices is yet another inclusion in the general scope of the original concept of CSA (FAO, 2013).

Besides agro forestry, intercropping system is also considered to be a better CSA technique. It is profitable since they could grow two or more different plants in the same time and it increases diversity, assures ecological balance, more utilization of natural resources, enhancement and sustainability in agricultural production (Maitra et al., 2019). Soil management, which is another CSA practice is a beneficial strategy in maintaining crop growth. It helps in developing soil performance using compost and manure by maintaining its fertility.

**Climate Smart Agriculture and Small holder farmers**

Climate adaptation helps in addressing the long-term impacts of climate change. Small holder farmers make use of CSA practices such as soil management,agro forestry,tree planting,inter-cropping system and balanced use of organic pesticides so as to minimize the negative impacts and improve the crop productivity. Soil-related farming activities increase the soil’s nutrients, positively affecting crop growth (Kuwornu et al., 2013).The age and education of the farmers influence the conservation techniques applied on the farm (Obayelu et al., 2014; Tazeze et al., 2012).farmers who have wider land are able to adopt more strategies and have more opportunities to improve their income (Belay et al., 2017). In addition, farmers’ cohesion is a key factor related to the social and cultural dimensions (Adger et al., 2013). Similar experiences in dealing with the local phenomena (Turasih & MKolopaking, 2016) contribute to the efforts of improving their prosperity and quality of life (Adger et al., 2013).

Transforming the traditional agricultural techniques, which prioritize productivity and show less concern on environmental degradation, into CSA, which enhances food security by conserving natural resources, requires improving the synergies and reducing the trade-offs between agricultural productivity and natural resources management. In this regard, developing the infrastructure and capacity for the farmers through financial investment, such as by collaborating with private sectors, plays a significant role (FAO, 2010).

The ability to prepare for climate disturbance, recovering from shocks and distress, and grow from destructive experiences is defined as climate resilience (World Bank, 2021; Obrist et al., 2010; Djalante & Thomalla, 2011). Climate resilience through CSA practices can be developed by utilizing ecosystem services. For instance, farmers implement agroforestry that combines trees and shrubs in forests and gardens. On one side, this technique gives direct benefits to them, such as improving their income and diversifying food productivity. On the other side, it provides merits to the environment, such as preventing erosion, increasing the infiltration rate and biodiversity, and balancing the ecosystem (FAO, 2010). These advantages enable farmers to be more flexible to cope with nuisances in their surrounding areas due to climate change.

Several indicators for assessing the benefits of CSA practices are formulated as follows (FAO, 2017a; Kpadonou et al., 2017):

1. Improvement of agricultural productivity;

 2. Improvement of resilient crops to climate variability;

 3. Improvement of soil fertility;

4. Improvement of income from crop diversification;

5. Improvement of water and soil conservation;

 6. Improvement of irrigation system for drought prevention;

7. Improvement of forest area that applies CSA practices

8. Improvement of farmers’ awareness of environmental protection

**STUDY UNIT- KUTTANAD**

The southern Indian state of Kerala is a narrow strip of land extending from the Western Ghats into the Arabian Sea. Kuttanad is a wetland zone that is situated around the Vembanad lake and is spread across the districts of Alappuzha,Kottayam and Pathanamthitta districts. It is one of the major flood prone areas in the state as the region is very ecologically sensitive. It is thickly populated as well as one of the main rice producing tracts in the state spread over the area of 1100 km sq in the deltaic region of the five Western Ghats River basins. In Kuttanad, the paddy farming system is situated 0-3 metres below the sea level, and is acknowledged by the Food and Agriculture Organisation (FAO) as a Globally Important Agricultural Heritage System. A series of artificial embankments are constructed for preventing saltwater intrusion and floodwater entry into the fields so as to make farming in Kuttanad possible. Rice production is characterised in this ecosystem by the active involvement of strong community institutions like the farmers' collective 'padasekhara samiti'. Major ecological problems faced by Kuttanad can be attributed to the mismanagement of its hydrological regime.

Kuttanad paddy farming system, which is declared as the 'Globally Important Agricultural Heritage System' by the U.N. (Koohafkan and Altieri, 2010) is a part of the largest wetland complex and Ramsar site in India, the Vembanad-Kol ecosystem (Ramsar, 2014). The paddy fields in this region, is situated 0-3 metres below the sea level and are enclosed by artificial embankments. Kuttanad is often referred to as the "Holland of the East" because of its resemblance to the Dutch landscape. The entire region is a mosaic of backwaters, rivers and numerous waterways and canals, extensive paddy field polders enclosed by dykes and coconut groves interspersed with multi-cropped homesteads (Sreejith, 2013). This region can be classified into 6 agro-ecological zones: Upper Kuttanad,Lower Kuttanad,North Kuttanad,Kayal lands,Purakkad and Vaikom Kari lands. Kuttanad farmers uses the method of advancing,whereby,the land is expanded into water by the use of dikes.

Kuttanad regularly suffers from natural disasters like flooding as well as salt water intrusion that limits the growing season to a few months. Though 14.5% of the state’s land area is prone to floods, the 2018 August floods were the worst in about a century, resulting in the death of 433 persons and destroying infrastructure and livelihood worth USD3.8 billion. Over 65,000 ha of land was inundated and 1259 out of 1664 villages across all the 14 districts of Kerala were affected by the flood (Government of Kerala, 2019). Climate change in the form of variability in climate like floods and its impact on the agriculture has to be studied and the resilient mechanisms such as crop management, crop improvement and crop protection strategies should be adapted to mitigate the negative effects of climate change as well as for sustainable agricultural production.



**CLIMATE SMART AGRICULTURE IN KUTTANAD**

Kuttanad is one of the few regions where rice is produced below the mean sea level and is also known as the rice granary of Kerala. It is a unique fragile ecological unit whose vulnerability can be attributed to the issues of water logging and soil acidity along with the climatic changes. They are facing the issues of crop damage due to summer rains and due to floods in the monsoon time.Thus,Kuttanad is a region where climate variations and natural calamities needs to be mitigated. Kuttanad followed a unique rice cultivation system which is of more than 150 years, developed by farmers of that region. Farming operations were dependant on the local water cycle. Sowing was done in the beginning of the northeast monsoon and harvest was completed before the southwest monsoon. Purely organic fertilizers were used, native varieties of crops were cultivated and there was no chemical application in the field. They cultivated only one crop in a year and the paddy fields were kept fallow between successive crops so that the soil could regain its fertility. Thus,inorder to mitigate the climatic variation and natural calamities,farmers in Kuttanad need to blend traditional methods with the climate smart farming methods.

**CONCLUSION**

Farmers face the challenges of climate change. Food security is an important concern of the present world with growing population. Adoption of climate resilient farming practices is the need of the hour and, climate smart agriculture is a better option in this regard. It would need less skill and resources on the part of the farmer, whereas it would help in increasing productivity as well as in mitigating the negative effects of climate change. Though the adoption of climate smart farming by the entire farming community might take time, it is a necessity to spread the awareness of climate smart farming at this hour of climate changes and natural disasters.

**REFERENCES**

 Abera, N., & Tesema, D. (2019). Perceptions and Practices of Climate Change Adaptation and Mitigation Strategies among Farmers in the Konta Special District, Ethiopia.

*Environmental & Socio-Economic Studies*, *7*(4), 1–16. https://doi.org/10.2478/environ- 2019-0019

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O’Brien, K. (2013). Cultural Dimensions of Climate Change Impacts and Adaptation. *Nature Climate Change*, *3*(2), 112–117. https://doi.org/10.1038/nclimate1666

Aminah, S., Sumardjo, Lubis, D., & Susant, D. (2015). Strategi Peningkatan Keberdayaan Petani Kecil menuju KetahananPangan. *Sosiohumaniora*, *18*(3), 253–261.

Anderegg, W. R. L., Trugman, A. T., Bowling, D. R., Salvucci, G., & Tuttle, S. E. (2019).

Plant Functional Traits and Climate Influence Drought Intensification and Land– atmosphere Feedbacks. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(28), 14071–14076. https://doi.org/10.1073/pnas.1904747116

Aqil, M., Andayani, N., & Z, B. (2013). Inovasi Teknologi Adaptasi Tanaman Jagung Terhadap Perubahan Iklim. *Seminar Nasional Inovasi Teknologi Pertanian*, (Puslitbangtan 2012), 39–48.

Arsad, E. (2015). Teknologi Pengolahan Dan Manfaat Bambu. *Jurnal Riset Industri Hasil Hutan*, *7*(1), 45. https://doi.org/10.24111/jrihh.v7i1.856

Asdak, C. (2010). *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Yogyakarta: Gadjah Mada University Press.

Assan, A. (2019). Strategi Bertahan Hidup Petani Gurem Kabupaten Kutai Barat. *EJournal Sosiatri-Sosiologi*, *7*(3), 54–67.

Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of Smallholder Farmers’ Adaptation Strategies to the Effects of Climate Change: Evidence from Northern Uganda. *Agriculture and Food Security*, *10*(1), 1–14. https://doi.org/10.1186/s40066-020-00279-1

Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder Farmers’ Sdaptation to Climate Change and Determinants of Their Adaptation Decisions in the Central Rift Valley of Ethiopia. *Agriculture and Food Security*, *6*(1), 1–13. https://doi.org/10.1186/s40066-017-0100-1

Berhanu, Y., Angassa, A., & Aune, J. B. (2021). A System Analysis to Assess the Effect of Low-cost Agricultural Technologies on Productivity , Income and GHG Emissions in Mixed Farming Systems in Southern Ethiopia. *Agricultural Systems*, *187*, 102988. https://doi.org/10.1016/j.agsy.2020.102988

BMKG. (2021). *Monthly Rainfall in Bantur Sub-district*. Malang District. BPS. (2018). *Hasil Survey Pertanian Antar Sensus (SUTAS) 2018*. Jakarta.

BPS. (2020). Statistik Indonesia 2020 Statistical Yearbook of Indonesia 2020. *Statistical Yearbook of Indonesia*, (April), 192.

Cacho, O. J., Moss, J., Thornton, P. K., Herrero, M., Henderson, B., Bodirsky, B. L., … Lipper, L. (2020). The Value of Climate-resilient Seeds for Smallholder Adaptation in Sub-Saharan Africa. *Climatic Change*, *162*(3), 1213–1229. https://doi.org/10.1007/s10584-020-02817-z

Carter, N., Bryant-Lukosius, D., Dicenso, A., Blythe, J., & Neville, A. J. (2014). The Use of Triangulation in Qualitative Research. *Oncology Nursing Forum*, *41*(5), 545–547. https://doi.org/10.1188/14.ONF.545-547

Devendra, C., & Thomas, D. (2002). Smallholder Farming Systems in Asia. *Agricultural Systems*, *71*(1–2), 17–25. https://doi.org/10.1016/S0308-521X(01)00033-6

Dinas Pertanian dan Ketahanan Pangan. (2019). *Rencana Strategis ( Renstra ) Tahun 2019-2024*. Surabaya.

Dinas Pertanian dan Ketahanan Pangan Kabupaten Sragen. (2018). *Perbedaan Pupuk Urea dan ZA*. Retrieved from http://journal.stainkudus.ac.id/index.php/equilibrium/article/view/1268/1127%[0Ah](http://p/)tt[p://p](http://p/) ublicacoes.cardiol.br/portal/ijcs/portugues/2018/v3103/pdf/3103009.pdf%[0Ah](http://www/)tt[p://www](http://www/)

.scielo.org.co/scielo.php?script=sci\_arttext&pid=S0121- 75772018000200067&lng=en&tlng=

Djalante, R., & Thomalla, F. (2011). Community Resilience to Natural Hazards and Climate Change: A Review of Definitions and Operational Frameworks. *Asian Journal of Environment and Disaster Management (AJEDM) - Focusing on Pro-Active Risk Reduction in Asia*, *03*(03), 339. https://doi.org/10.3850/s1793924011000952

DLH Provinsi Jawa Timur. (2018). *Profil ProKlim Provinsi Jawa Timur 2017*. Surabaya. Falatehan, A. F., Syaukat, Y., Hastuti, & Nasrullah, N. (2021). Paddy Loss and Its

Implication to Fertilizer Subsidy in Indonesia. *Hayati Journal of Biosciences*, *28*(1), 73– 82. https://doi.org/10.4308/hjb.28.1.73

FAO. (2010). *Climate-Smart Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. https://doi.org/10.1111/j.1467-825x.2009.02642.x

FAO. (2013). *Climate-Smart Agriculture Sourcebook*. Food and Agriculture Organization of the United Nations.

FAO. (2017a). Key Messages Monitoring and Evaluation for Climate-smart Agriculture :

Scope, Purposes, Frameworks and Concepts. Retrieved from

<http://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/module-> c9-monitoring-evaluation/c9-overview/en/

FAO. (2017b). *Tracking Adaptation in Agricultural Sectors*. https://doi.org/10.18356/87fe25de-en

FAO & Ministry of Agriculture Livestock and Fisheries. (2018). *Climate-Smart Agriculture - Training Manual for Agricultural Extension Agents in Kenya*.

Georgia Pacific. (1999). Water & Forests: The Role Trees Play in Water Quality. *Educational in Nature*, *1*(2), 1–6. Retrieved from https:/[/www](http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5269813.pdf).[fs.usda.gov/Internet/FSE\_DOCUMENTS/stelprdb5269813.pdf](http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5269813.pdf)

Hairiah, K., Cipto, S., Utami, S. R., Purnomosidhi, P., & Roshetko, J. M. (2004). Diagnosis Faktor Penghambat Pertumbuhan Akar Sengon (Paraserianthes falcataria L. Nielsen) pada Ultisol di Lampung Utara. *Agrivita*, *26*(1), 89--98.

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., … MacKinnon, J. L. (2014). Extreme Vulnerability of Smallholder Farmers to Agricultural Risks and Climate Change in Madagascar. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1639), 1–12. https://doi.org/10.1098/rstb.2013.0089

Harvey, C. A., Saborio-Rodríguez, M., Martinez-Rodríguez, M. R., Viguera, B., Chain- Guadarrama, A., Vignola, R., & Alpizar, F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. *Agriculture and Food Security*, *7*(1), 1–20. https://doi.org/10.1186/s40066-018-0209-x

Herlina, N., & Prasetyorini, A. (2020). Effect of Climate Change on Planting Season and Productivity of Maize (Zea mays L.) in Malang Regency. *Jurnal Ilmu Pertanian Indonesia*, *25*(1), 118–128. https://doi.org/10.18343/jipi.25.1.118

Herlinawati. (2013). Adaptasi Petani pada Banjir Musiman di Desa Mojodadi Kecamatan Kedungpring Kabupaten Lamongan. *Swara Bhumi E-Journal Pendidikan Geografi FIS Unesa*, *2*(1), 187–196.

Ho, T. T., & Shimada, K. (2019). The Effects of Climate Smart Agriculture and Climate Change Adaptation on the Technical Efficiency of Rice Farming—An Empirical Study

in the Mekong Delta of Vietnam. *Agriculture (Switzerland)*, *9*(99), 1–20. https://doi.org/10.3390/agriculture9050099

IPCC. (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,*.

ITS News. (2021). *Dorong UMKM Desa, Abmas-KKN ITS Rakit Alat Pengering Mi Porang*. Retrieved from https:/[/www](http://www.its.ac.id/news/2021/04/10/dorong-ukm-desa-kkn-its-rakit-).[its.ac.id/news/2021/04/10/dorong-ukm-desa-kkn-its-rakit-](http://www.its.ac.id/news/2021/04/10/dorong-ukm-desa-kkn-its-rakit-) mesin-pengering-mi/

Jamil, I., Jun, W., Mughal, B., Raza, M. H., Imran, M. A., & Waheed, A. (2021). Does The Adaptation of Climate-Smart Agricultural Practices Increase Farmers ’ Resilience to Climate Change ? *Environmental Science and Pollution Research*, (21). https://doi.org/https://doi.org/10.1007/s11356-021-12425-8

Kemendagri. (2018). *Batas Daerah*. Jakarta.

Kementerian PPN/Bappenas. (2019). Rencana Pembangunan Jangka Menengah Nasional 2015-2019. In *Rencana Pembangunan Jangka Menengah Nasional 2020-2024*.

Kerala Agricultural University. (2019). Report of soil analysis in Alappuzha and Kottayam districts. Prepared by RARS, Kumarakom. 2019. Thrissur, Kerala 1:3.

Kholis, I., & Setiaji, K. (2020). Analisis Efektivitas Kebijakan Subsidi Pupuk Pada Petani Padi. *Economic Education Analysis Journal*, *9*(2), 503–515. https://doi.org/10.15294/eeaj.v9i2.39543

Kpadonou, R. A. B., Owiyo, T., Barbier, B., Denton, F., Rutabingwa, F., & Kiema, A. (2017).

Advancing Climate-Smart-Agriculture in Developing Drylands: Joint Analysis of The Adoption of Multiple On-farm Soil and Water Conservation Technologies in West African Sahel. *Land Use Policy*, *61*, 196–207. https://doi.org/10.1016/j.landusepol.2016.10.050

Krisnawati, H., Varis, E., Kallio, M., & Kanninen, M. (2011). Paraserianthes falcataria (L.) Nielsen: Ekologi, Silvikultur dan Produktivitas. In *CIFOR*. Bogor, Indonesia.

Kumparan. (2019). *Mengenal Macam Pupuk Bersubsidi dan Kegunaannya*. Retrieved from: https://kumparan.com/techno-geek/mengenal-macam-pupuk-bersubsidi-dan- kegunaannya- 1551364997932978224/full.

Kusumaningrum, S. I. (2019). Pemanfaatan Sektor Pertanian sebagai Penunjang Pertumbuhan Perekonomian Indonesia. *Jurnal Transaksi*, *11*(1), 80–89. Retrieved from <http://ejournal.atmajaya.ac.id/index.php/transaksi/article/view/477/283>

Kuwornu, J. K. M., Al-Hasan, R. M., Etwire, P. M., & Osei-Owusu, Y. (2013). Adaptation Strategies of Smallholder Farmers to Climate Change and Variability: Evidence from Northern Ghana. *Information Management and Business Review*, *5*(5), 233–239. https://doi.org/10.22610/imbr.v5i5.1047

Leuning, R., Kriedemann, P. E., & McMurtrie, R. E. (1991). Simulation of Evapotranspiration by Trees. *Agricultural Water Management*, *19*(3), 205–221. https://doi.org/10.1016/0378-3774(91)90042-H

Luo, Z., Guan, H., Zhang, X., Zhang, C., Liu, N., & Li, G. (2016). Responses of Plant Water Use to A Severe Summer Drought for Two Subtropical Tree Species in The Central Southern China. *Journal of Hydrology: Regional Studies*, *8*, 1–9. https://doi.org/10.1016/j.ejrh.2016.08.001

Maitra, S., Palai, J. B., Manasa, P., & Kumar, D. P. (2019). Potential of Intercropping System in Sustaining Crop Productivity. *International Journal of Agriculture Environment and Biotechnology*, *12*(1), 39–45. https://doi.org/10.30954/0974-1712.03.2019.7

Mbuli, C. S., Fonjong, L. N., & Fletcher, A. J. (2021). Climate Change and Small Farmers’ Vulnerability to Food Insecurity in Cameroon. *Sustainability*, *13*(1523), 1–16.

Ministry of Agriculture. *Regulation of The Minister of Agriculture Number 49 of 2020 on Allocation and The Highest Retail Price of Subsidized Fertilizers for The Agricultural*

*Sector for The 2021 Fiscal Year*. , (2020).

Ministry of Agriculture. *Decree of the Minister of Agriculture Number 01 of 2021 on Guidelines for Paddy Farming Insurance Premium Assistance (AUTP) for Fiscal Year 2021*. , (2021).

Nasrin, M., Bauer, S., & Arman, M. (2018). Assessing the Impact of Fertilizer Subsidy on Farming Efficiency: A Case of Bangladeshi Farmers. *Open Agriculture*, *3*(1), 567–577. https://doi.org/10.1515/opag-2018-0060

Neufeldt, H., Jahn, M., Campbell, B. M., Beddington, J. R., Declerck, F., Pinto, A. De, … Zougmoré, R. (2013). Beyond Climate-smart Agriculture : Toward Safe Operating Spaces for Global Food Systems. *Agriculture & Food Security*, *2*(12), 1–6. Retrieved from <http://www.agricultureandfoodsecurity.com/content/2/1/12>

Obayelu, O. A., Adepoju, A. O., & Idowu, T. (2014). Factors Influencing Farmers’ Choices of Adaptation to Climate Change in Ekiti State , Nigeria. *Journal of Agriculture and Environment for International Development - JAEID*, *108*(1), 3–16. https://doi.org/10.12895/jaeid.20141.140

Obrist, B., Pfeiffer, C., & Henley, R. (2010). Multi-layered Social Resilience: A New Approach in Mitigation Research. *Progress in Development Studies*, *10*(4), 283–293. https://doi.org/10.1177/146499340901000402

Olawuyi, S. O. (2020). Heterogeneous Treatment Effect Estimation of Participation in Collective Actions and Adoption of Climate-smart Farming Technologies in South – West Nigeria. *GeoJournal*, *85*(5), 1309–1323. https://doi.org/10.1007/s10708-019-

10024-2

Petrokimia Gresik. (2019). *SP-36*. Retrieved from: https://petrokimia- gresik.com/product/pupuk-sp-36?hl=en.

PMM UMM. (2020). *Video Profil Desa Rejosari Kec. Bantur Kab. Malang - PMM UMM Kel. 86 Gel. 7*. [Video File]. Youtube. https:/[/www](http://www.youtube.com/watch?v=bY3qn4I9Cak).[youtube.com/watch?v=bY3qn4I9Cak.](http://www.youtube.com/watch?v=bY3qn4I9Cak)

Pramono, A. A., Fauzi, M. A., Widyani, N., Heriansyah, I., & James M., R. (2011). Managing Smallholder Teak Plantations: Field guide for farmers. In *Managing smallholder teak plantations: Field guide for farmers*. https://doi.org/10.17528/cifor/003493

Pratiwi, H. (2013). Pengaruh Kekeringan Pada Berbagai Fase Tumbuh Kacang Tanah. *Buletin Palawija*, (22), 71–78. https://doi.org/10.21082/bulpalawija.v0n22.2011.p71-78

Ramamasy, S., & Baas, S. (2007). *Climate Variability and Change: Adaptation to Drought in Bangladesh, A Resource Book and Training Guide*. Rome, Italy: Asian Disaster Preparedness Center FoodOand Agriculture Organization of The United Nations.

Republic of Indonesia. *Law of The Republic of Indonesia Number 19 of 2013 on The Protection and Empowerment of Farmers in Indonesia*. , Pub. L. No. 19 (2013).

Rondhi, M., Pratiwi, P. A., Handini, V. T., Sunartomo, A. F., & Budiman, S. A. (2018).

Agricultural Land Conversion, Land Economic Value, and Sustainable Agriculture: A Case Study in East Java, Indonesia. *Land*, *7*(148), 1–19. https://doi.org/10.3390/land7040148

Saputra, F. D., & Mustafidah, H. (2016). Sistem Pakar Menentukan Tingkat Kecocokan Lahan Untuk Tanaman Jati Menggunakan Metode Forward Chaining ( The Expert System Determine About Fitting Grade Of The Field For Tectonic Grandis By Forward Chaining Methode ). *Juita*, *IV*(1), 37–47.

Saputra, Y. H. (2018). Kasus Pertanian Wilayah Pinggiran Kota Bandung. *Sepa*, *14*(2), 146– 158.

Sari, R. R., Hairiah, K., & Suyanto, S. (2018). Karakteristik Hutan Rakyat Jati dan Sengon Serta Manfaat Ekonominya di Kabupaten Malang. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *2*(2), 129–137. https://doi.org/10.21776/ub.jepa.2018.002.02.6

Saubani, A. (2017). *Apa Itu Hujan Tipuan yang Turun di NTT? Ini Penjelasan BMKG*. Retrieved from https://republika.co.id/berita/nasional/daerah/17/09/19/owira5409-apa- itu-hujan-tipuan-yang-turun-di-ntt-ini-penjelasan-bmkg.

Shahzad, A., Ullah, S., Dar, A. A., Sardar, M. F., Mehmood, T., Tufail, M. A., … Haris, M. (2021). Nexus on Climate Change: Agriculture and Possible Solution to Cope Future Climate Change Stresses. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-12649-8

Shanabhoga, M. B. (2020). *Adaptation Strategies by Paddy-growing Farmers to Mitigate the Climate Crisis in Hyderabad-Karnataka Region of Karnataka State, India*. *12*(5), 541– 556. https://doi.org/10.1108/IJCCSM-01-2020-0010

Soekartawi. (1984). Sebuah Catatan tentang Definisi Petani Besar dan Kecil. *Jurnal Agro Ekonomi*, *3*(2), 11–17.

Solikin. (2013). Pertumbuhan Vegetatif dan Generatif Stachytarpeta jamaicensis (L.) Vahl.

*UPT Balai Konservasi Tumbuhan Kebun Raya Purwodadi - LIPI*, 1–6.

Suryani, E., & Dariah, A. (2012). Peningkatan Produktivitas Tanah Melalui Sistem Agroforestri. *Jurnal Sumberdaya Lahan*, *6*(2), 101–109. https://doi.org/10.2018/jsdl.v6i2.6394

Susanti, E., Surmaini, E., & Estiningtyas, W. (2018). Parameter Iklim sebagai Indikator Peringatan Dini Serangan Hama Penyakit Tanaman. *Jurnal Sumberdaya Lahan*, *12*(1), 59–70.

Susilowati, S. H., & Maulana, M. (2012). Luas Lahan Usahatani dan Kesejahteraan Petani : Eksistensi Petani Gurem dan Urgensi Kebijakan Reforma Agraria Farm Business Land Size a nd Farmers ’ Welfare : Smallholders ’ Existence and Agrarian Reform Urgency Lahan pertanian dewasa ini menghadapi tanta. *Analisis Kebijakan Pertanian*, *10*(1), 17– 30.

Tazeze, A., Haji, J., & Ketema, M. (2012). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. *ISSN*, *3*(14), 2222–1700. Retrieved from [www.iiste.org](http://www.iiste.org/)

Thirdyawati, N. S., Suharjono, & Yulianti, T. (2013). Pengaruh Rotasi Tanaman dan Agen Pengendali Hayati terhadap Nematoda Parasit Tanaman. *Biotropika*, *1*(5), 211–215.

Turasih, & M Kolopaking, L. (2016). Srategi Adaptasi Perubahan Iklim pada Petani Dataran Tinggi (Studi Petani di Dataran Tinggi Dieng, Kabupaten Banjarnegara). *Sodality: Jurnal Sosiologi Pedesaan*, *4*(1). https://doi.org/10.22500/sodality.v4i1.14408

UNFCCC. (2007). Climate Change:Impacts, Vulnerabilities and Adaptation in Developing Countries. In *United Nations Framework Convention on Climate Change* (Vol. 5). https://doi.org/10.1002/2017EF000539

USAID APIK. (2017). *Laporan Kajian Kerentanan dan Risiko Iklim Provinsi Jawa Timur*.

Malang.

Vignola, R., Harvey, C. A., Bautista-Solis, P., Avelino, J., Rapidel, B., Donatti, C., & Martinez, R. (2015). Ecosystem-based Adaptation for Smallholder Farmers: Definitions, Opportunities and Constraints. *Agriculture, Ecosystems and Environment*, *211*, 126–132. https://doi.org/10.1016/j.agee.2015.05.013

Widnyana, K. (2012). Bambu Dengan Berbagai manfaatnya. *Bumi Lestari*, *8*(1), 1–10. https://doi.org/10.2307/j.ctt46nrzt.12

Wiyono, S. (2007). *Perubahan Iklim, Pemicu Ledakan Hama dan Penyakit Tanaman*. Bogor. World Bank. (2011). *Climate-Smart Agriculture: A Call to Action*.

World Bank. (2021). *Resilience Rating System, A Methodology for Building and Tracking Resilience to Climate Change*. https://doi.org/10.1596/35039