ASSESSMENT OF AGRICULTURAL RESIDUE FROM MAJOR CROPS IN THE PHILIPPINES

FRANCIS C. HIZOLE
LISETTE P. MUNCAL

An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines in Partial Fulfillment of the Requirements for the Degree of

BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING
(AB Process Engineering)

JUNE 2023

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

LIST OF APPENDIX FIGURES

ABSTRACT

HIZOLE, FRANCIS C. and MUNCAL, LISETTE P., Department of Agricultural and Biosystems Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, **FEBRUARY 2023, ASSESSMENT OF AGRICULTURAL RESIDUE FROM MAJOR CROPS IN THE PHILIPPINES**

Adviser: ELMAR M. VILLOTA, Ph.D.

Agricultural production has increased more than three times in the last 50 years. However, rapid population growth led to higher demand for food and later became a driving force for agricultural intensification. Due to this intensified agricultural production, significant growth of agricultural waste residues was observed. These wastes, when utilized, can be converted into more useful products that can promote sustainability of energy supply. Thus, this study was conducted to assess the volume of agricultural residues from major agricultural crops in the Philippines namely rice, corn, sugarcane and coconut. The study used secondary data which include 2012-2021 production volume of major agricultural crops extracted from Philippine Statistics Authority and estimation values of different agricultural residues retrieved from selected literatures. Results of the study revealed that the major agricultural residues from rice, corn, sugarcane and coconut were rice straw, corn stalk, bagasse and coconut shell respectively. Using GIS, the data collected were presented through choropleth maps to show the spatial distribution of major agricultural residues on a regional basis.

Keywords: agricultural residues, rice, corn, sugarcane, coconut

LITERATURE CITED

Abinaya, K., Rajkishore S.K., Lakshmanan A. & Anandham R. (2021). Synthesis and characterization of carbon dots from coconut shell by optimizing the hydrothermal carbonization process. *Journal of Applied and Natural Science, 13*(4), 1151 - 1157. https://doi.org/10.31018/jans.v13i4.2916

Agamuthu, P. (2009). Challenges and opportunities in Agrowaste management: An Asian perspective. Inaugural meeting of First Regional 3R Forum in Asia 11 -12 Nov., Tokyo, Japan.

Alauddin, Md., Islama, J., Shirakawaa H., Kosekib T., Ardiansyahc, & Komaia M. (2017). Rice bran as a functional food: An overview of the conversion of rice bran into a superfood/functional food. Superfood and Functional Food - An Overview of Their Processing and Utilization. doi: 10.5772/66298

Altoveros, N.C. & Borromeo T.H. (2007). The state of the plant genetic resources for food and agriculture of the Philippines (1997-2006). https://www.fao.org/3/i1500e/Philippines.pdf

Alvarez, F., Manalo A. & Clarete, R. (2021). Economic assessment of GM corn use in the Philippines. *International Journal of the Science of Food and Agriculture, 5*(1), 115-128.

Ang, P. A. (2019). Philippines sugar annual situation and outlook. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Sugar%20Annual_Manila_Philippines_4-15-2019.pdf

Aranoudov, V. & Sibayan, E.B., (n.d.). Adaptation and mitigation initiatives in Philippine rice cultivation. https://unfccc.int/files/focus/mitigation/application/pdf/amia_philippines.pdf?fbclid=IwAR0qAdy3yjRoYnVJ7fEqpJSK72PVMrzistkkb1jzHFaB7IAqSSxFRTuhpP4

Balat, M. & Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy, 86*(11), 2273–2282. doi:10.1016/j.apenergy.2009.03.015 10.1016/j.apenergy.2009.03.015

Balomajumder, C., Gupta, N. & Tripathi, S. (2011). Characterization of pressmud: A sugar industry waste. *Fuel, 90,* 389-394. doi: 10.1016/j.fuel.2010.08.021.

Batangas-Philippines.com (n.d). A sweet grass – The sugarcane. http://www.batangas-philippines.com/sugarcane.html

Bello, S. & Agunsoye, J. & Adebisi, J. & Kolawole, F. & Hassan, B. (2016). Physical properties of coconut shell nanoparticles. *Journal of Science, Engineering and Technology, 12,* 63-79. doi: 10.3126/kuset.v12i1.21566.

Bharagava, R. N. (Ed.). (2020). Emerging eco-friendly green technologies for wastewater treatment. microorganisms for sustainability. doi: 10.1007/978-981-15-1390-9

Briones, R.M. (2021). Philippine agriculture: Current state, challenges, and ways forward. https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidspn2112.pdf?fbclid=IwAR3RvKz1Ya2J13utihtCI2SqYcj46HrKQbtt2sx1Tyb7IG65elnjz2Gd2ks

Britannica. (n.d). Corn. https://www.britannica.com/plant/corn-plant

Brunerová, A., Roubík, H., Brožek, M., Van Dung D., Phung L. D., Hasanudin U., Herák D. (2020). Briquetting of sugarcane bagasse as a proper waste management technology in Vietnam. *Waste Management & Research*, *38*(11), 1239–1250. https://doi.org/10.1177/0734242X20938438

Caputo, A. C., Palumbo, M., Pelagagge, P. M., and Scacchia, F. (2005). Economics of biomass energy utilization in combustion and gasification plants: Effects of logistic variables. *Biomass & Bioenergy*, *28,* 35–51.

Chernet, M., Haddis, A. & Genet, B. (2016). Study session 7 solid waste: Sources, composition and on-site storage. https://tinyurl.com/ynm24yc6

Crossman, Ashley. (2023). The difference between the mean, median, and mode. https://www.thoughtco.com/measures-of-central-tendency-3026706

Cutshall, A. (1958). Philippine agriculture: Summary and trends. *The Professional Geographer, 10*(5), 2-4. doi: 10.1111/j.0033-0124.1958.105_2.x

De los Santos, W. L., Lansigan, F. P. & Hansen, J. (2022). linking corn production climate information and farm level decision making: A case study in Isabela Philippines. https://www.climate-policy-watcher.org/climate-forecasts/linking-corn-production-climate-information-and-farmlevel-decisionmaking-a-case-study-in-isabela-philippines.html

Department of Environment and Natural Resources (DENR). (2016). Regional profile: Physical and socio-economic profile. https://calabarzon.denr.gov.ph/index.php/about-us/regional-profile

Dhankhar, P. (2014). Rice milling. *IOSR Journal of Engineering, 4*(5), 34-42.

Duke, J. (1983). Oryza sativa l. http://www.hort.purdue.edu/newcrop/duke_energy/oryza_sativa.html

Dy, R.T. & Reyes, S. (n.d.). The Philippine coconut industry: performance, issues and recommendations. https://pdf.usaid.gov/pdf_docs/Pnadh939.pdf

Elepaño, A., Demafelis, R., Dorado, M., Bataller, B., Badayos, R., Pampolina, N., Baticados E.J. & Gatdula, K. (2015). Potential bioenergy production from major agricultural residues in the Philippines. *Philippine Journal of Crop Science, 40,* 49-61.

Entrepreneur India (n.d.) Uses of sugarcane bagasse and its based products. https://www.entrepreneurindia.co/project-and-profile-listing?CatId=2273&SubCatId=2274&CatName=Sugar%20Production,%20Sugarcane%20Processing%20and%20Byproducts,%20Sugarcane%20Industry%20Waste%20Utilization,%20Growing,%20Milling,%20Refining,%20Sugarcane%20Bagasse,%20Sugarcane%20Juice,%20Sugarcane%20Molasses,%20Jaggery,%20Ethanol on October 27, 2022.

Environmental Systems Research Institute. (n.d.). Why is data management important? https://www.esri.com/en-us/arcgis/products/data-management

Esa, N.M., Ling, T.B. & Peng, L.S. (2013). By-products of rice processing: An overview of health benefits and applications. *J Rice Res, 1*(107). doi: 10.4172/jrr.1000107

Exconde, O.R., (n.d.). Corn in the Philippines: Its production and research activities with emphasis on downy mildew. https://www.jircas.go.jp/sites/default/files/publication/tars/tars8-_21-30.pdf

Food and Agriculture Organization of the United Nations (FAO). (2017). Strategic work of FAO for sustainable food and agriculture. http://www.fao.org/3/ai6488e.pdf.

Food and Agriculture Organization (FAO). (2020). FAOStat. Rome, Italy: FAO. http://faostat.fao.org

Food and Agriculture Organization of the United Nations (FAO). (n.d.). Restoring coconut farmers' livelihoods in the Philippines. https://www.fao.org/in-action/restoring-coconut-farmers-livelihoods-in-the-philippines/en/

Gazmin, M. & Infante, J. (2018). Cagayan Valley's amaizeing corn products: Increasing income of farmers through value adding. Department of Agriculture – Regional Field Office No. 02 – Research Division Nursery Compound, San Gabriel, Tuguegarao City, Cagayan.

Geoscope Philippines (n.d.). Isabela. https://geoscopesite.wordpress.com/isabela/

Gerpacio, R. & Labios, J. & Labios, R. & Diangkinay, E. (2004). *Maize in the Philippines: Production Systems, Constraints, and Research Priorities*. Mexico, D. F.: CIMMYT.

Ghulam S, Khan MJ, Usman K, Shakeebullah (2012). Effect of different rates of press mud on plant growth and yield of lentil in calcareous soil. *Sarhad J Agric, 28*(2), 249–252.

Gupta N, Tripathi S, Balomajumder C (2011) Characterization of press mud: a sugar industry waste. *Fuel, 90*(1), 389–394.

Hirschey, P. J. (2003). Could rice hulls be a valuable commodity? http://deltafarmpress.com/rice/could-rice-hulls-be-valuable-commodity.

GISGeography. (2023). What is GIS? A guide to Geographic Information Systems. https://gisgeography.com/what-is-gis/

Go, A. W., Conag, A. T., Igdon, R. M. B., Toledo, A. S. & Malila, J. S. (2019). Potentials of agricultural and agro-industrial crop residues for the displacement of fossil fuels: A Philippine context. *Energy Strategy Reviews, 23,* 100–113. doi:10.1016/j.esr.2018.12.010

Gonzales, B.P. (1970). Analysis and pulping of coir dust. R. Emata (Ed.), *Coconut Research and Development* (pp. 163-173). UCAP, Manila.

Habito, C. & Briones, R. (2005). Philippine agriculture over the years: Performance, policies and pitfalls 1. https://www.researchgate.net/publication/265248373_Philippine_Agriculture_over_the_Years_Performance_Policies_and_Pitfalls_1

Huke, R. (1982). Rice Area by Type of Culture: South, Southeast, and East Asia. Los Baños (Philippines): International Rice Research Institute.

India Infoline. (n.d.). By-products of sugarcane. https://content.indiainfoline.com/wc/archives/sect/suin/ch10.html

InsightsIAS. (2019). Why govt is encouraging ethanol production?. https://www.insightsonindia.com/2019/11/08/why-govt-is-encouraging-ethanol-production/

International Rice Research Institute (IRRI). (n.d.). Rice straw management https://www.irri.org/rice-straw-management

Iqbal, N., Agrawal, A., Dubey, S., & Kumar, J. (2021). Role of decomposers in agricultural waste management. biotechnological applications of biomass. doi: 10.5772/intechopen.93816

James, A. & Yadav, D. (2021). Valorization of coconut waste for facile treatment of contaminated water: A comprehensive review (2010-2021). *Environmental Technology & Innovation, 24,* 1-20

Jamir, L., Kumar, V., Kaur, J., Kumar, S. & Singh, H. (2021). Composition, valorization and therapeutical potential of molasses: a critical review. *Environmental Technology Reviews, 10*(1), 131-142, DOI: 10.1080/21622515.2021.1892203

Joachim, A.W.R. (1930). The fertilizer value and decompositability of coconut fiber dust. *Chemical Abstracts*, *24,* 1796.

Kim, S., & Dale, B. E. (2004). Global potential bioethanol production from wasted crops and crop residues. *Biomass and Bioenergy*, *26*(4), 361–375. doi:10.1016/j.biombioe.2003.08.002

Kumar, V., Chopra, A.K. (2016). Effects of sugarcane pressmud on agronomical characteristics of hybrid cultivar of eggplant (Solanum melongena L.) under field conditions. *International Journal of Recycling of Organic Waste in Agriculture, 5,* 149–162. https://doi.org/10.1007/s40093-016-0125-7

Koul, B., Mohammad, Y. & Shah, M. (2022). Agricultural waste management strategies for environmental sustainability. *Environmental Research*, 206. https://doi.org/10.1016/j.envres.2021.112285.

Luh, B. S. (1991). Chapter 13: Rice oil in Rice Production, 2nd Edn., ed S. B. Luh (New York City, NY: Springer Publishing), 714–730. doi: 10.1007/978-1-4899-3754-4

Maji, S., Dwivedi, D.H., Singh, N., Kishor, S., Gond, M. (2020). Agricultural waste: Its impact on environment and management approaches. In: Bharagava, R. (eds) emerging eco-friendly green technologies for wastewater treatment. *Microorganisms for Sustainability*, Vol 18. Springer, Singapore. https://doi.org/10.1007/978-981-15-1390-9_15

Mapping and Geographic Information Systems (GIS): *What is GIS?*. (n.d.). University of Wisconsin-Madison. https://researchguides.library.wisc.edu/GIS

Marcus, J.M. (2013). Food Science Basics: Healthy cooking and baking demystified. https://www.sciencedirect.com/science/article/pii/B9780123918826000029

Moreno, M., Kuwornu, J. & Szabo, S. (2020). Overview and constraints of the coconut supply chain in the Philippines. *International Journal of Fruit Science, 20,* 5524-5541. doi: 10.1080/15538362.2020.1746727

Mui, N. T., Preston, T. R. & Binh, D. V. (1997). Sugar cane tops as a feed for goats; effect of harvest season. *Livestock Research for Rural Development, 9*(1). http://www.lrrd.org/lrrd9/1/mui91.htm

National Geographic. (n.d.). GIS (Geographic Information System). https://education.nationalgeographic.org/resource/geographic-information-system-gis

Nations Encyclopedia. (n.d.) Philippines-agriculture. https://www.nationsencyclopedia.com/economies/Asia-and-the Pacific/PhilippinesAgriculture.html

Obeng, G. Y., Amoah, D. Y., Opoku, R., Sekyere, C. K. K., Adjei, E. A. & Mensah, E. (2020). Coconut wastes as bioresource for sustainable energy: Quantifying wastes, calorific values and emissions in Ghana. *Energies, 13*(9), 2178. doi:10.3390/en13092178

Obi, F., Ugwuishiwu, B. & Nwakaire, J. (2016). Agricultural waste concept, generation, utilization and management. *Nigerian Journal of Technology, 35*(4), 957-964.

Panyakaew, S. & Fotios, S. (2011). New thermal insulation boards made from coconut husk and bagasse. *Energy Build*, *43*(7), 1732-1739.

Paturau, J.M. (n.d.). Alternative uses of sugarcane and its by-products in agro-industries. https://www.fao.org/3/s8850e/S8850E03.htm

Philippine Biomass Energy Laboratory. (2000). Biomass energy resource atlas of the Philippines.

Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (n.d.). *Coconut*. https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/coconut/#:~:text=Major%20producers%20of%20coconut%20in,(VCO)%20and%20desiccated%20coconut.

Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (n.d.). Sugarcane. https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/sugarcane/#:~:text=The%20sugarcane%20industry%20contributes%20not,annually%20to%20the%20Philippine%20economy.

Philippine Statistics Authority. (2013). Rice and corn situation outlook. https://psa.gov.ph/sites/default/files/ricorsit_oct2013.pdf

Philippine Statistics Authority. (2015). Rice and corn situation outlook. https://psa.gov.ph/sites/default/files/ricorsit_jan2015.pdf

Philippine Statistics Authority. (2016). Rice and Corn Situation Outlook. https://psa.gov.ph/sites/default/files/ricorsit_january2016_1.pdf

Philippine Statistics Authority. (2017). Rice and corn situation outlook. https://psa.gov.ph/sites/default/files/SR-PCPS%28Jan2017%20rd%29_updated-ALL-2.pdf

Philippine Statistics Authority. (2018). Crops statistics of the Philippines 2012-2016. https://psa.gov.ph/sites/default/files/Crops%20Statistics%20of%20the%20Philippines%2C%202012-2016.pdf

Philippine Statistics Authority. (2023). Crops Statistics of the Philippines 2017-2021. https://psa.gov.ph/sites/default/files/Crops%20Statistics%20of%20the%20Philippines%2C%202017-2021.pdf

Philippine Statistics Authority. (2018). Rice and corn situation outlook, January 2018. https://psa.gov.ph/sites/default/files/Rice%20and%20Corn%20Situation%20and%20Outlook%20Report%2C%20January%202018_0.pdf

Philippine Statistics Authority. (2019). Rice and corn situation outlook. https://psa.gov.ph/sites/default/files/Rice%20and%20Corn%20Situation%20and%20Outlook%2C%20January%202019_0.pdf

Philippine Statistics Authority. (2020). Performance of Philippine agriculture (April-June 2020). https://www.da.gov.ph/performance-of-philippine-agriculture-april-june-2020/

Pogosa, J., Asio, V., Bande, M., Bianchi, S., Pichelin, F. & Grenz, J. (2018). Productivity and sustainability of coconut production and husk utilization in the Philippines: Coconut husk availability and utilization. *International Journal of Environmental and Rural Development*, *9*(1), 31-36.

Raghavan, K. (2010). Biofuels from coconuts. Fact Foundation: Wageningen, the Netherlands.

Raza, Q.-U.-A., Bashir, M. A., Rehim, A., Sial, M. U., Ali Raza, H. M., Atif, H. M., Brito, A. F. & Geng, Y. (2021). Sugarcane industrial byproducts as challenges to environmental safety and their remedies: A review. *Sustainable Management of Water and Wastewater, 13*(24), 3495. https://doi.org/10.3390/w13243495

Reddy, G.P.O. (2018). Spatial data management, analysis, and modeling in GIS: Principles and applications. In Reddy G. & Singh S. (Eds.), Geospatial technologies in land resources mapping, monitoring and management. *Geotechnologies and the Environment*, vol 21. Springer, Cham. https://doi.org/10.1007/978-3-319-78711-4_7

Requiso, P., Nayve, Jr. F. R., Alfafara, C., Ventura, R.L., Escobar, E. & Ventura, J. (2018). Agricultural residue feedstock selection for polyhydroxyalkanoates production using AHP-GRA. *Philippine Journal of Science, 147*(4), 693-704.

Rice Knowledge Bank (n.d.). By-products. http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products#:~:text=The%20main%20by%2Dproducts%20of,and%20the%20grains%20are%20threshed.

Rice Knowledge Bank (n.d.). Rice bran. http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products/rice-bran

Rice Knowledge Bank (n.d.). Rice husk. http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products/rice-husk

Rice Knowledge Bank (n.d.). Rice straw. http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products/rice-straw

Ritchie, H., Rosado, P. & Roser, M. (2023). Agricultural production. *Our world in data.* https://ourworldindata.org/agricultural-production

Roberts, M.G., Dawe, D., Falcon, W.P. & Naylor, R.L. (2009). El Niño-Southern Oscillation impacts on rice production in Luzon, the Philippines. *Journal of Applied Meteorology and Climatology, 48*(8), 1718-1724.

Romallosa, A. & Kraft, E. (2017). Feasibility of biomass briquette production from municipal waste streams by integrating the informal sector in the Philippines. *Resources, 6*(1), 12. doi:10.3390/resources6010012

Romulo, N. A. (2013). Market and trade of coconut products. *Asian and Pacific Coconut Community:* Thailand, 1-122.

Sardar, S, Ilyas, S.U., Malik, S.R., Javaid K (2013). Compost fertilizer production from sugar press mud (SPM). *Intl J Microb Res, 1*(2), 20–27.

Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F. & Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: Policies and facts. *Environmental Development, 15,* 3-34.

Sevilla, F.M. (2021). Sugar annual. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Sugar%20Annual_Manila_Philippines_04-15-2021

Shinners, K.J. & Binversie, B.N. (2007). Fractional yield and moisture of corn stover biomass produced in the Northern US corn belt. *Biomass Bioenergy, 31,* 576-584. https://doi.org/10.1016/j.biombioe.2007.02.002

Singh, P., Dubey, P., Younis, K. et al. (2022). A review on the valorization of coconut shell waste. *Biomass Conversion and Refinery*. https://doi.org/10.1007/s13399-022-03001-2

Sivakumar, K. & Krishna Mohan N. (2010). Performance analysis of downdraft gasifier for agriwaste biomass materials. *Indian Journal of Science and Technology, 3,* 58-60.

Sokhansanj, S., Turhollow, A., Cushman, J., & Cundiff, J. (2002). Engineering aspects of collecting corn stover for bioenergy. *Biomass and Bioenergy, 23*(5), 347–355. doi:10.1016/s0961-9534(02)00063-6

Statista Research Department. (2022). Coconut production volume Philippines 2012-2021. https://www.statista.com/statistics/751403/philippines-coconut-production/

Statista Research Department. (2022). Corn production volume Philippines 2012-2021. https://www.statista.com/statistics/751372/philippines-corn-production/#:~:text=Corn%20production%20volume%20Philippines%202012%2D2021&text=In%202021%2C%20the%20production%20volume,tons%20in%20the%20previous%20year "Sugarcane." Merriam-Webster.com Dictionary,

Sumners, M. D., Jenkins B.M., Hyde P.R., Williams J.F., Mutters R.G., Scardacci S.C. & Hair M.W. (2003). Biomass production and allocation in rice with implications for straw harvesting and utilization. *Biomass & Bioenergy*, *24*(3), 163–73. https://doi.org/10.1016/S0961-9534(02)00132-0

Tan, B.L., Norhaizan, M.E. (2020). Production of rice by-products. In: Rice by-products: phytochemicals and food products application. *Springer, Cham.* https://doi.org/10.1007/978-3-030-46153-9_3

Tejano, E. A. (1985). State of the art of coconut coir dust and husk utilization: general overview. *Philippine Journal of Coconut Studies, 2,* 4-11.

Tooy, D., Nelwan, L. & Pangkerego, F. (2014). Evaluation of biomass gasification using coconut husks in producing energy to generate small-scale electricity. Int'l conference on artificial intelligence, energy and manufacturing engineering. June 9-10, 2014 Kuala Lumpur (Malaysia).

Toppr.com (n.d.). What is the ideal temperature for sugarcane cultivation?. https://www.toppr.com/ask/question/what-is-the-ideal-temperature-for-sugarcane-cultivation/

Tripathi, N., Hills, C.D., Singh, R.S. & Atkinson, C.J. (2019). Biomass waste utilization in low-carbon products: Harnessing a major potential resource. *Climate and Atmospheric Science*, *2*(1), 1–10.

Ugwuoke, C., Monwuba, N., Onu, F., Shimave, A., Okonkwo, E. & Opurum, C. (2018). Impact of agricultural waste on sustainable environment and health of rural women. *Civil and Environmental Research*, *10*(9), 1-9.

United Nations Development Programme. (2015). Adaptation and mitigation initiatives in Philippine rice cultivation. https://unfccc.int/files/focus/mitigation/application/pdf/amia_philippines.pdf?fbclid=IwAR0qAdy3yjRoYnVJ7fEqpJSK72PVMrzistkkb1jzHFaB7IAqSSxFRTuhpP4

United States Department of Agriculture. (2021). Sugar annual. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Sugar%20Annual_Manila_Philippines_04-15-2021#:~:text=Sugarcane%20is%20concentrated%20on%20Negros,60%20percent%20of%20total%20production.

USDA Foreign Agricultural Service. (2014). Philippines: Biofuels annual. *Global agricultural information network.* https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_Manila_Philippines_10-22-2014.pdf&fbclid=IwAR2D1qOFW2yCe7tk77s7V2CFmik98idX62VISuNkMhhZJ-lkaicDto3mO0I

USDA Foreign Agricultural Service. (2016). Philippines: Drought in Mindanao causes corn production decline. *Commodity Intelligence Report.* https://ipad.fas.usda.gov/highlights/2016/03/Philippines/Index.htm

USDA Foreign Agricultural Service. (2015). Philippines: Oilseeds and products annual. Global agricultural information network. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Oilseeds%20and%20Products%20Annual_Manila_Philippines_4-22-2015.pdf_&fbclid=IwAR3sX8C5nmmb_-VMreTjcn6KTPE5bXShe8kz0DQsfUVwKVQpzWWsnqTRazs

USDA Foreign Agricultural Service. (2018). Philippines: Oilseeds and products annual. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Oilseeds%20and%20Products%20Annual_Manila_Philippines_3-16-2018.pdf&fbclid=IwAR2BBDximX0KpLAxO7kCcdn6BpO6V5xlkeoeoyOu0NLOdOiHeoII__FFgcg

USDA Foreign Agricultural Service. (2019). Philippines: Oilseeds and products annual. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Oilseeds%20and%20Products%20Annual_Manila_Philippines_3-20-2019.pdf&fbclid=IwAR0-6h-eJO4EiZ6Xh88LRPuQmIaptFjcSZ-_4TApn4SrVtIuC0UKUIjXq-8

USDA Foreign Agricultural Service. (2019). Philippines: Grain and feed annual. *Global Agricultural Information Network.* https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Grain%20and%20Feed%20Annual_Manila_Philippines_3-8-2019.pdf

USDA Foreign Agricultural Service. (2020). Philippines: Grain and feed annual. *Global Agricultural Information Network.* https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Grain%20and%20Feed%20Annual_Manila_Philippines_03-19-2020

USDA Foreign Agricultural Service (2021). Grain and feed annual. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Grain%20and%20Feed%20Annual_Manila_Philippines_03-19-2021

USDA Agriculture Foreign Agricultural Service. (2021). Philippines: Oilseeds and products annual. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Oilseeds%20and%20Products%20Annual_Manila_Philippines_04-01-2021.pdf&fbclid=IwAR3GkFkESv6qJEWL_L69N6jCNixv2VY3zdBvsBHmTsi6vWT1SNTMsMCGbGM

USDA Foreign Agricultural Service. (n.d). Philippines sugar annual situation and outlook. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Sugar%20Annual_Manila_Philippines_4-21-2016.pdf

USDA Foreign Agricultural Service. (2017). Philippines sugar annual situation and outlook. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Sugar%20Annual_Manila_Philippines_4-6-2017.pdf

USDA Foreign Agricultural Service. (2019). Philippines sugar annual situation and outlook. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Sugar%20Annual_Manila_Philippines_4-15-2019.pdf

USDA Foreign Agricultural Service. (2021). Philippines sugar annual situation and outlook. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Sugar%20Annual_Manila_Philippines_04-15-2021.pdf

What is a choropleth map?. (n.d.). Caliper. https://www.caliper.com/glossary/what-is-a-choropleth-map.htm

Wikifarmer. (n.d.). Rice field and soil preparation. https://wikifarmer.com/rice-field-and-soil-preparation/

Zafar, S. (2021). Agricultural wastes in the Philippines. *Bioenergy Consult.* https://www.bioenergyconsult.com/agricultural-resources-in philippines/#:~:text=The%20most%20common%20agricultural%20wastes,husk%2C%20coconut%20shell%20and%20bagasse