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Water-Surplus Productivity Improvements In Agrarian Emerging Pacific Island Economies

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Abstract - The aggregate rainfall in the Pacific is comparatively higher than in many economies relative to the land area. This contributes to a lot of rainfall and water surplus zones with its added impact on the soil, ultimately agricultural productivity. Having water surplus zones presents a significant opportunity to capture, store, re-purpose and invest the water for maximum agricultural productivity. Due also to climate change and other natural disasters, the region is prone to spells of dry weather at different times in the year. A majority of the economies within the region are agrarian-invested and reliant. However, one of the challenges faced is the limited technological advancement of integrated systems in agriculture in the region. This report reviews available literature and presents some of the possible improvements that could be made within the water-surplus emerging Pacific Island Economies in Agriculture.

Keywords — agricultural productivity, climate change, improvements, natural disasters, pacific, rainfall, water surplus.

I. INTRODUCTION

In traditional and modern Agricultural systems of production, water is a very important input. The dynamic water demands for irrigation, and other non-agricultural purposes, have increased in line with the growing population and industrialization in many areas. A positive relationship has been found to exist between agricultural output and the availability of water (Mondol et al 2022). However whilst some agricultural sectors have suffered water scarcity with a possibility of facing droughts in the future, other regions face water surplus, a potential for land erosion and flooding due to the climate change and other factors. Water deficit results from insufficient water supply, and in places where the demand for freshwater exceeds its supply (Deng and Zhao 2015). Water surplus results from excess water supply compared to the demand and needs. Under both scenarios, developing better irrigation systems and enhancing their efficiency improves crop productivity,

The Pacific Islands have been experiencing comparatively higher temperatures, variations in rainfall patterns, rising sea levels, changes in frequency and the intensity of extreme climate events. Further changes are expected long into the future. These changes are occurring on top of the naturally variable climate due to climate change and human actions. These are estimated to affect communities, the environment, human health, infrastructure, coastal resources, disaster management, fresh water availability, agriculture, fisheries, forestry, marine ecosystems and tourism (Pacific-Australia, 2015). The projections for the future are that agriculturally impacting drought and the negative impact of surplus water may increase (Jentsch and Beierkuhnlein, 2008, Goodess, 2013). Agricultural water requirements in especially the water deficit areas are expected to increase due to the variability in precipitation and surface water supplies (Kang et al., 2009). For example, in Bangladesh the average rice yield is projected to decrease by 33% by 2050 due to rainfall variability (Mondol et al 2022). Five case studies from across the Pacific over the 31-year period of 1989-2019, suggests that extreme daily rainfall intensity in the Pacific is changing (ADB 2021). Although the impact projected of the rainfall variability is dependent on crops, the expected variation from the effects of temperature variations is projected to be more prominent than the rainfall. The expectation is that there will be a positive impact of Carbon Dioxide fertilisation on crop growth, from climate change and higher water demand, which will lead to an agricultural production median reduction of 57% by 2090 (Elliott et al., 2013).

Although a number of research have been conducted mostly on the impacts of climate change on Agriculture, only a handful have focused on water surplus in the Pacific or the drought severity or intensity and its impacts on the capacity for agricultural development and growth. Around 80% of all Pacific Islanders still rely on agricultural produce from their own gardens or from smallholder farmers to support or to supplement their diets (Georgeou et al 2022). So far, there has been no comprehensive study on the impact of water surplus on agriculture in the pacific economies. In this paper, an analysis is provided focusing on adapting agriculture with developed technology in a surplus water supply region, how agriculture-dependent countries can encourage entrepreneurship through the focus on the services and goods that could be produced with the development in this area, which will ultimately bridge the agricultural development gap between the pacific and the highly productivite agrarian development sectors of the west.

II. THE PACIFIC AGRICULTURAL CHARACTERISTICS

In recent decades, there has been an Increased reliance and consumption in the Pacific region of imported goods which may reflect an update in the tastes and reduction in food security, and agrarian challenges. The Pacific Islander with a relatively higher rainfall has adapted to these by cultivating local food crops, and expanding domestic asset creation that promotes economic development, especially for women (Georgeou et al 2022). However, agriculture is still vital in many of the Pacific Island economies as it is the predominant source of sustenance as well as a major export earner in many communities. Various factors like the smallness and remoteness of the Pacific Island countries appear to have hindered and continue to hinder their economic development in the world economy (Malua 2003). Agriculture in the Pacific region which is a major earner is generally confined to smallholder farms and household gardens. Its sustainability is threatened by nutrient imbalances, erosion, declining soil fertility and carbon, and climate change(ACIAR 2021). Sustainability measures are urgently needed in addition to resource development if the current yields are to be maintained and improved for the foreseeable years.

Globally, irrigation issues exist where there are not enough rain water catchment systems or the engagement of the most advanced technology that help reduce the loss of water or waste of limited water resources. The regularity of and quantity of rainfall in an area makes agriculture and crop cultivation much easier. Within the Pacific region, a variety of tropical crops and other forms of agriculture can thrive in the region as rain and surplus water provides sustainable growth for the crops that feed the livestock like cows, goats, pigs, sheep and other animals. Smallholder farmers in Fiji and Papua New Guinea are engaged in exporting honey and by-products whilst sheep and goat production in Pacific island countries could be improved(ACIAR 2021). In Vanuatu, meat exports are processed through 3 vertically integrated abattoirs. The plant-based raw material needed for fish farming is also provided by the availability of rain, whilst crop farming also receives the much needed water for irrigation purposes. Statistically, the Western Pacific Ocean, near New Guinea and Australia receives heavy rain, however the strategy of supplemental irrigation which is a vital key towards maximum productivity and generating income in an agrarian economy is still underutilised in many areas. Irrigation water productivity is reported as being higher and suggested to be used alongside rainwater for maximum productivity.

Whilst the summers are warm, oppressive, wet, and overcast In Cook Islands; the winters are comfortable, muggy, and partly cloudy; and it is windy year round. Rain falls throughout the year in Cook Islands. The most rainfall occurs in Cook Islands in January, with an average rainfall of 6.8 inches(Weatherspark, 2022). Due to the location of Micronesia, Federated States, the strong influence of the northeast trade winds, it experiences a tropical climate, rainfall is high on primarily during the wet season with annual totals exceeding 400 inches (1,016 cm) and up to 22 inches (559 mm) in a given day (Climate knowledge 2022). Annual rainfall in Fiji's dry zones averages around 2000mm, whereas in the wet zones, it ranges from 3000 mm around the coast to 6000mm on the mountainous sites. Average annual rainfall in Kiribati is approximately 2100 mm whilst in Nauru the amount varies due to the long droughts and the average annual rainfall is about 200 cm (79 inches). In the wet, rainfall in the Marshall Islands is heavy and can average as 160 inches (1,524 mm) per year, while in the dry seas, it may average 20 inches (508 mm). The yearly average rainfall in Nuie amounts to around 2,000mm (79 inches) and in Palau it is around 3,800 millimeters (150 inches) per year.

Rainfall in Papua New Guinea typically ranges from 2,000 to 4,000 millimeters (80 to 160 inches) per year, whilst Samoa's annual mean rainfall ranges from 3000 to 6000 millimeters with about 70% observed during the Hot and Wet season. The average annual rainfall in Solomon Island is mostly within the range 3000 to 5000 millimetres with the majority of monthly rainfall amounts in excess of 200 millimetres whilst the average rainfall in Timor-Leste is approximately 1500 mm per year. Precipitation in Tonga gradually decreases from north to south, from about 2,400 to about 1,600 millimeters (95 to 63 inches) per year. The mean annual rainfall in the southern islands of Tuvalu is 3,400 mm while in the north it is 2,900 mm. Vanuatu's climate varies with latitude, from wet tropical in the northern islands, which receive over 4,000 millimeters (mm) of annual rainfall to the dryer subtropical in the southern extremes of the archipelago, where annual average rainfall measures 1,500 mm. The above statistics and facts provide direction and hope, mainly for agricultural and hydrological planning and irrigation and drainage projects purposes. Surplus runoff water can be made available through water harvesting and used for the irrigation of various crops, livestock, and animal farming in the region on a wider scale.

Having a lot of water available throughout the year does have its pros and cons for agriculture. One of the major problems it can have is the depletion of nutrients and soil quality which may also have a negative impact on especially the crops, the land, the vegetation and other geography that the agricultural sector depends on. Thornthwaite and Mather in 1957 proposed the climatological water balance method of using the soil water holding capacity, rainfall and the potential evapotranspiration data as input which has been a useful tool for agricultural planning (Sentelhas et al, 2008). Subsequently, there is a need within the region to invest into research in the various economies on the influence and impact of the surplus water on the available agricultural lands. Further research could also be done on the impact on the crops and the crops that may be best suited for the changing

landscape. In assessing a location's characteristics for drought or water surplus, it is reasonable to not only monitor and consider the precipitation, but also the other meteorological parameters such as evapotranspiration in the area (Gocic, and Trajkovic 2014). Evapotranspiration is believed to return approximately 60–80% of rain back to the atmosphere and the land. This, guarantees more water being put back into the water cycle and thus into agriculture in the region.

One of the other issues is marine pollution, be it plastic, oil or of other kinds. The flow and run-off of rainwater towards the rivers and seas also do carry a lot of matter. In the Pacific, we find the so-called "Great Pacific Garbage Patch", a massive plastic accumulation area found at the center of an ocean gyre (Harse 2011). All living things in that area and the path that the water and garbage runs off towards the sea and rivers will all be affected. This is mostly caused by littering and marine debris discharged in the sea, intentionally or not.

III. PACIFIC ISLANDS AND THEIR LAND MASS

Country	Most Recent Year	Most Recent Value
Fiji	2020	18,270
Kiribati	2020	810
Marshall Islands	2020	180
Micronesia, Fed. Sts.	2020	700
Nauru	2020	20
Palau	2020	460
Samoa	2020	2,780
Solomon Islands	2020	27,990
Tonga	2020	720
Tuvalu	2020	30
Vanuatu	2020	12,190
Papua New Guinea	2020	452,860
Nuie	2020	262
Cooks Island	2020	240
American Samoa	2020	200

SOURCES: WORLD BANK 2022

From the above table, many of the economies within the Pacific have a significantly smaller land area which is being used for the development of homes, businesses, transport network, government buildings, tourist sites and other very important structures. In addition to this, the impact of global warming and climate change is having an impact on the land erosion and sea level rising to reclaim part of the land. The result is that the portion of land available for agriculture is relatively significantly smaller in the region. In many cases, it is expected that water deficit can be predicted, avoided, or mitigated similarly. Water surplus and its impact on agriculture can also be predicted, avoided and mitigated in many cases. This thus leads to the importance of developing important water treatments, irrigation channels, and other research and developmental efforts that ensure the optimum productivity that can be realised from agriculture is not reduced..

IV. THE NEED FOR WATER TREATMENT SYSTEMS

At the beginning of the 19th century, the early settlers of Jerusalem encountered extreme heat, a catastrophically barren and desert land. However their desire to make the area liveable and sustainable was strong enough to lead to developments in agriculture, development of water wells and research into their fresh water needs were thus conducted. Their challenge was a decrease in rainfall and limited water sources which had a negative potential impact on their agriculture. After the much needed investments, 50 percent of Israel's total water consumption is now from desalinated sea water(Becker, Lavee and Katz 2010). This of course does have a subsequent impact on agriculture cultivation and production. Wind, precipitation and evaporation patterns greatly influence the salinity of the surface waters of the Pacific Ocean. The lowest salinities, which is less than 32 parts per thousand, occur in the far north of the Pacific. With so much available sea water in the Pacific, desalination will lead to a material increase in the freshwater supply. This may not be an area of significant investment at the moment due to the amount of freshwater already available in the region through rainfall. However, agricultural decision makers in the Pacific Region, can take a cue from the successes and work done to solve the fresh water problems just listed and provide their own solutions based on their unique problems.

Israel also uses other technologies for sustainable agriculture which includes recycled water technology where wastewater is recycled for use in agriculture. SInce in the year 2000, the country has invested over 750 million dollars in centralised water treatment which has added 37 billion gallons of water to the country's total water protection(Bar-Nahum et al 2021). There are 67 large wastewater treatment plants of which 10 treat more than 56% of waste collection. Water from the largest facility is used to irrigate about 60 percent of their agricultural lands in the Negev desert. 90 percent of the water is recycled. The Pacific Ocean is one of

the three biggest bodies of water on the planet and the largest of all bodies of water, occupying almost 30% of the Earth's surface which provides a great opportunity for such investment (UNESCO 2022). This covers 165,250,000 square km (63,800,000 sq. mi), roughly 46% of the water surface on the planet. The average depth of the Pacific Ocean is 4,280 m (14,040 ft), and it contains the deepest known spot on the planet: Challenger Deep in the Mariana Trench, east of the Philippines, at 11,034 m (36,201 ft.). This provides a great case for desalination of water. There is a great opportunity to put a lot of water reclaimed from the sea, rain and other water bodies into productive inputs for agriculture like has been done in Israel.

Another development that has allowed Israel to turn deserts to farm lands is the drip irrigation. The hydraulic engineers proposed modern technology to allocate moisture and water directly to the roots of the crops. The Isrealy drip technology is now being used in 109 countries like the Philippines and Tanzania. The Netafim irrigation technology is reported to save between 25-75 percent of water compared to classic irrigation (Salz 2015). One of the benefits of using this advanced irrigation system is that there's a higher coefficient of water used by the drip comparable to the traditional watering process. A significant part of the Israely land is located in the desert. The land is not suitable for farming similar to the same challenges of engaging in agriculture in a area with excess water and a lot of rain. Whilst in the desert lands, plants are only able to absorb limited water and not much of the nutrients in the excess water cases, the crops potentially lose a lot of their nutrients to excess water and continues rain. The Isrealy solution was to solve the problem with the use of mushrooms and similar appropriate research may also generate the appropriate solution for the Pacific. The combined workings of the mushrooms and the plants help absorb nutrients which would otherwise have been missed to provide better yields.

As a general rule, the winter months in the South Pacific are dry and pleasant, whereas the summer months, from November to April, are scorching and rainy. Tropical cyclones and other atmospheric disturbances make the western tropical Pacific the largest region on Earth of high rainfall recording more than 80 inches (200 centimeters) per year. The Pacific Northwest gets about seven feet of precipitation a year(Climate Knowledge 2022). As most part of the Pacific Ocean is found in low latitudes, its climate is mostly tropical and subtropical. In the Eastern Pacific, there are two subtropical, semi-permanent high-pressure cells. This then makes it ideal for the cultivation of some crops and unsuitable for some others. The introduction of greenhouse, and other modern agricultural practices could open up further crop cultivation within the region. Other research into retaining soil nutrients and maintaining the nutrients in the water surplus irrigation and farming systems could also be an area to explore for maximum agricultural productivity.

It is suggested that the availability of freshwater for agricultural use is sufficient to meet the needs by 2050, however this depends on the corresponding cohesion with proper technology, investment, and the appropriate agricultural and management systems. Bangladesh with an almost constant water deficit during winter and maximum water deficits in the pre-monsoon and post-monsoon periods found that the correlation between crop water surplus/deficit, and meteorological drought weakens over time due mainly to the irrigation development(Mondol et al 2022). In reviewing the severity and frequency of water deficits, possibly as a result of climate change or variability, and its impact on rice production in Bangladesh, it was found that regardless of the water deficit, rice production was positively correlated with irrigation. In China, Groundwater reservoirs are used for both local precipitation and surplus water which is captured from the Han River Basin and has been an effective method for preventing the further lowering of the groundwater table(Du, Su, and Zhang 2013). The development and increased use of advanced irrigation techniques is something that could also be explored in the Pacific especially with the record of rain that falls. Some of the water that is in excess can generate revenue if sold to the water deficit regions.

V. CONCLUSIONS

On record, some parts of the world experience water deficit and droughts which does have an impact on agriculture especially where advanced irrigation techniques are not yet employed. However, other regions of the world like the Pacific, receive a lot of rainfall annually in addition to the possibility of engaging in desalination to increase their freshwater supplies. The factors contributing to the rainfall includes the fact that most parts of the Pacific Ocean are found in low latitudes, whilst its climate is mostly tropical and subtropical. In the Eastern Pacific, there are two subtropical, semi-permanent high-pressure cells. Additionally, the Pacific Ocean often experiences tropical cyclones, or typhoons. All of these lead to the Pacific Northwest receiving about seven feet of precipitation a year.

Taking a cue from the benefits of the Technology used in Israel like recycling water supply system, desalinating systems, drip irrigation that all work perfectly in the same country. It may be a very economic decision to explore water research areas that could potentially increase the yields that are being generated from agriculture in the region. Further research into how to safeguard the soil nutrients and how to put the surplus water that the region enjoys to more economically rewarding alternatives.

REFERENCES

[1] ACIAR 2021, Pacific island countries, https://www.aciar.gov.au/publication/aop2021/pacific-island-countries, accessed 27 October 2022

[2] ADB, 2021, Interim Guidance for the Pacific, Accounting for Changes in Extreme Daily Rainfall Intensity in Pacific Island Countries, DOI: http://dx.doi.org/10.22617/ARM210446-2,

[3] Bar-Nahum Ziv, Reznik Ami, Finkelshtain Israel, Kan Iddo, 2021, Centralized water management under lobbying: Economic analysis of desalination in Israel, Ecological Economics, Volume 193, 2022, 107320, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2021.107320.

[4] Climate knowledge 2022, Micronesia, Fed. Sts., https://climateknowledgeportal.worldbank.org/country/micronesia-fed-sts/, accessed 27 October 2022

[5] Deng et al., (2015), Identification of water scarcity and providing solutions for adapting to climate changes in the Heihe River Basin of China, Adv. Meteorol.

[6] Du, S., Su, X., & Zhang, W. (2013). Effective storage rates analysis of groundwater reservoir with surplus local and transferred water used in S hijiazhuang C ity, C hina. Water and Environment Journal, 27(2), 157-169.

[7] Elliott et al, 2013, Constraints and potentials of future irrigation water availability on agricultural production under climate change, Potsdam Institute for Climate Impact Research, 111 (9) 3239-3244, https://doi.org/10.1073/pnas.1222474110

[8] Gocic, M., & Trajkovic, S. (2014). Drought characterisation based on water surplus variability index. Water resources management, 28(10), 3179-3191.

[9] Georgeou N, Hawksley C, Wali N, Lountain S, Rowe E, West C, et al. (2022) Food security and small holder farming in Pacific Island countries and territories: A scoping review. PLOS Sustain Transform 1(4): e0000009, https://doi.org/10.1371/journal.pstr.0000009

[10] Harse, Grant A, 2011, Plastic, the Great Pacific Garbage Patch, and International Misfires at a Cure, https://doi.org/10.5070/L5292019968,

[11] Jentsch et al., (2008), Research frontiers in climate change: effects of extreme meteorological events on ecosystems, Comptes Rendus Geosci.

[12] Kang et al., (2009), Climate change impacts on crop yield, crop water productivity and food security - a review, Progressive National Science.

[13] Becker N., Lavee D. and Katz D., 2010, Desalination and Alternative Water-Shortage Mitigation Options in Israel: A Comparative Cost Analysis, Journal of Water Resource and Protection, Vol. 2 No. 12, pp. 1042-1056. doi: 10.4236/jwarp.2010.212124.

[14] Malua Margaret, 2003, THE PACIFIC ISLANDS - UNCTAD, https://unctad.org/system/files/official-document/ditctncd20031p5_en.pdf, accessed 27 October 2022

[15] Mondol, M. A. H., Zhu, X., Dunkerley, D., & Henley, B. J. (2022). Changing occurrence of crop water surplus or deficit and the impact of irrigation: An analysis highlighting consequences for rice production in Bangladesh. Agricultural Water Management, 269, 107695.

[16] Pacific-Australia, 2015, Climate in the Pacific: A regional summary of new science and management tools, Pacific-Australia Climate Change Science and Adaptation Planning Program, https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/Climate-in-the-Pacific-summary-48pp_WEB.pdf, accessed 27 October 2022

[17] Salz, R.. (2015). Netafim, shaping the future. 35. 12-15.

[18] Sentelhas, P. C., dos Santos, D. L., & Machado, R. E. (2008). Water deficit and water surplus maps for Brazil, based on FAO Penman-Monteith potential evapotranspiration. Ambiente e Agua-An Interdisciplinary Journal of Applied Science, 3(3), 28-42.

[19] UNESCO 2022, Pacific Ocean: a Detailed Map, Marta Fava, accessed 11 October 2022, https://oceanliteracy.unesco.org/pacific-ocean/

[20] Weatherspark, 2022, Climate and Average Weather Year Round in Cook Islands, https://weatherspark.com/y/150214/Average-Weather-in-Cook-Islands-Year-Round, accessed 27 October 2022