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The Factors Influencing the Choices for Adaptation by Dairy Farmers to Climate Change in Fiji

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ABSTRACT

Climate change has greatly impacted Fiji's ecosystem including animal (livestock) and crop production from past decades and still greatly affects their economy. These climatic events include flooding, rise in ambient temperature, rise in the sea level, droughts, tropical cyclones, and all others that bring large changes to the environmental system. These large changes adversely affect animal production and the economy in Fiji. Not only this, but dairy farmers are also severely affected by climatic conditions such as loss of income and livestock species that die out during cyclones and other aspects. Not only the terrestrial species but the marine organisms are also affected since climatic changes bring alterations to their feeding period and the mating time leading to a vast decrease in organisms' health, quality, and population. Consequently, the Fijian government and other Pacific organizations have brought strategies like adaptation plans to implement in animal production sectors. These plans and methods will help farmers in stimulating their farming systems and adapting to climatic changes and hence, this will lead to increased productivity and economy. The aim and objective of this review are to define and elaborate the climatic change effects on livestock and marine production in Fiji and effective solutions adopted by Fiji and other Pacific governments to refrain from adverse climate conditions.

Keywords: Climatic events, Fijian government, Adaptation.

INTRODUCTION

Fiji is one of the small island nations in the Pacific Ocean. The island is widely known for its tropical climate and rich biodiversity. Many farmers practice dairy farming in Fiji as it well contributes to the country's economy. Dairy farming is an important industry in Fiji with a significant number of small-scale farmers producing milk and dairy products for local consumption and export. However, Fiji is vulnerable to the impacts of climate change, which affects all the dairy farmers and the dairy industry. For instance, rising temperatures, changing rainfall patterns, and increased frequency of extreme weather events are affecting the livelihoods of dairy farmers, making it challenging to maintain their productivity and profitability. To combat these challenges, dairy farmers in Fiji are making the best efforts and practices in adapting and mitigating the impacts of climate change.

Climate Change and Its Impacts on Dairy Farming in Fiji

Climate change is a global phenomenon affecting various sectors such as agriculture and dairy farming. It severely affects Fiji every year mainly with the droughts and flooding. It is expected that these changes will continue and intensify unless and until drastic action is taken to reduce greenhouse gas emissions

(Bhuiyan, 2018). It is known that the dairy farming industry in Fiji is particularly vulnerable to climate-related shocks due to its dependence on fragile agroecological systems (Oliveira Jr., 2017). A change in temperature and precipitation patterns can always alter the suitability of pasturelands for cattle grazing which can lead to a reduction in milk production and its quality (Hansen, 2012). Moving on, frequency increases because of extreme weather events for example severe floods and droughts can easily damage infrastructure, human livelihoods, and livestock health as well (Fiji Ministry of Agriculture, 2020).

Moreover, through the hardship of raising cattle, many dairy farmers have made adaptation choices to combat climate change. Such as irrigation, where installing irrigation systems to ensure the reliability of water supply during drought and when water scarcity arises. Diversification, for example, planting crops that are more resilient to climate-related stressors. In livestock management, farmers practice rotational grazing and breeding programs so that they can improve animal health and resilience. Lastly, in market diversification, farmers explore new market values for selling milk or milk products to reduce their dependence on traditional markets.

History of the Dairy Industry

History of Fiji's dairy industry- Fiji's dairy industry commenced after World War I when the Government acquired land to settle returning servicemen in the Central Division (Bennett et al., 2001). Then, milk was processed into butter (Cushman et al., 2013). By 1930 production exceeded local demand and the surplus was exported to the United Kingdom and Canada (Knapman et al.,1985). With the worldwide depression of the mid-nineteen thirties, the industry was seriously affected wherein all surplus milk was dumped on the local market. During this period, the dairy industry suffered huge setbacks. Despite the prevailing economic hard times; the dairy farmers and a few businessmen formed a cooperative and thereafter expanded its operations into producing sterilized milk in 1959 (Freckman et al.,1960).

Fiji Cooperative Dairy Company Limited (FCDCL was created under the Dairy Restructuring Decree in 2010 when the industry was restructured into two companies, FCDCL and Fiji Dairy Company (FDL)-Processor). FCDCL is owned by the dairy farmers of Fiji and is operated as a commercial company with its own Board of Directors and Chief Executive Officer. The company is responsible for the welfare and well-being of dairy farmers (Bank, 2013). The key functions are to make available supplement feeds, drugs, and farm inputs to farmers to improve their livelihood through dairy farming. Provision of technical support in animal health and animal husbandry to farmers. Subsidization of the cost of farm inputs such as copra, calf milk replacer, mill mix, and molasses through bulk purchase provision of the dairy industry and developmental services. Approximately 262 dairy farms are registered under FCDCL (Fiji Cooperative Dairy Company Limited database).

METHODOLOGY- MATERIALS AND METHODS

Study Site

A random sampling method will select households that keep dairy and poultry in Viti Levu and Vanua Levu. Data will be collected on the farmers' observations on climate change.

Study Design and Sample Size

Observations will be made on the changes in climate, availability of grazing, changes in livestock numbers and causes of those changes, the actions that they take to deal with these changes, and the assets available to them.

Data Collection

Information will be collected on factors influencing their adaptive capacity to deal effectively with changing climate and variability. The determinants that will be used to measure adaptive capacity on a Likert scale of 1(low) to 5 (high) will be information, technology, economic resources, institutions and social networks, infrastructure, and equity. The categorization will be determined as 1-2.9 - low, 3 – moderate, and an average ranking of 4 and above as high. These factors will then be ranked to determine their strengths on whether they become barriers or enablers to adaptation to climate change and variability. Further, the questionnaire will seek to understand the smallholder dairy and poultry farmers reasons for adopting these adaptation strategies their level of satisfaction with farm labor, and the observed trend in monthly income from the sale of dairy and poultry products.

Data Analysis

Quantitative data from the survey will be organized into percentages to show the effects of climate change on smallholder farmers (dairy) and the adaptive strategies employed by study respondents to climate

change effects. The data will then be subjected to a Principal Component Analysis (PCA), to identify factors that influence smallholder farmers' adaptation to climate change events. The factors that will have the highest proportionate influence, based on the Eigenvalues (accounting for 75% of the influence) will then be determined. Finally, one proportion Z-score test for proportions will be used to test for significant differences between the means of the climate change adaptation measures and the presumed mean (if 50% of respondents would adopt and the other 50% would not), to confirm if the differences are significant ($p<0.05$).

RESULTS

Animal Health and Production Workers' and Farmers' Perceptions of Diseases and Clinical Signs Are the Most At-Risk

Animal health and production workers' perception — Farmers' perception

Diseases at risk	Frequency	Proportion	Diseases at risk	Frequency	Proportion
Brucellosis	22	11.96%	Parasites	37	24.03%
Tuberculosis	18	9.78%	Flu/Cold	20	12.99%
Fowl pox	15	8.15%	Coccidiosis	20	12.99%
Scabies	14	7.61%	Scabies	18	11.69%
Endoparasites	9	4.89%	Fowl pox	13	8.44%
Avian Influenza	8	4.35%	Roundworms	7	4.55%
Ectoparasites	8	4.35%	Foot rot	7	4.55%
Foot and Mouth Disease	8	4.35%	Coryza	7	4.55%
Newcastle Disease	8	4.35%	Lice	5	3.25%
Pneumonia	8	4.35%	Anthrax	5	3.25%
Anthrax	7	3.80%	Bacterial infections	3	1.95%
Coccidiosis	7	3.80%	Tetanus	2	1.30%
Leptospirosis	7	3.80%	Mites	2	1.30%
Parasites	6	3.26%	Iron deficiency	2	1.30%
Rabies	6	3.26%	Clostridium	2	1.30%
Roundworms	6	3.26%	Asthma	2	1.30%
Flu/Cold	4	2.17%	Parvovirus	1	0.65%
Classical Swine Fever	3	1.63%	Marek's disease	1	0.65%
HPAI	3	1.63%			
Swine fever	3	1.63%			
American Foulbrood	2	1.09%			
Bacterial infections	2	1.09%			
Chronic Respiratory Diseases	2	1.09%			
Salmonellosis	2	1.09%			
Asthma	1	0.54%			
Avian Infectious Laryngotracheitis	1	0.54%			
Mites	1	0.54%			
Parvovirus	1	0.54%			
Trichinosis	1	0.54%			
Varroa mites	1	0.54%			

Clinical signs at risk	Frequency	Proportion
Diarrhea	36	33.03%
Skin issue	9	8.26%
Cough	7	6.42%
Weak	7	6.42%
Eye issue	5	4.59%
Growth Issue	5	4.59%
Fever	3	2.75%
Lameness	3	2.75%
Respiratory issue	3	2.75%
Anaemia	2	1.83%
Blood in stool	2	1.83%
Injuries/wounds	2	1.83%
Loss appetite	2	1.83%

Loss of weight	2	1.83%
Mastitis	2	1.83%
Mortality	2	1.83%
Nutrition issue	2	1.83%
Poor condition	2	1.83%
Swollen body	2	1.83%
Blindness	1	0.92%
Constipation	1	0.92%
Fluid in the joints/ the body	1	0.92%
Hair falling off	1	0.92%
Itchiness	1	0.92%
Nose discharge	1	0.92%
Paralysis	1	0.92%
Pecking	1	0.92%
Salivary mouth	1	0.92%
Sore body	1	0.92%
Vomiting	1	0.92%

DISCUSSIONS

Factors Affecting Dairy Farmer's Adaptation Choices

Several factors influence the choices made by dairy farmers in Fiji when adapting to climate change.

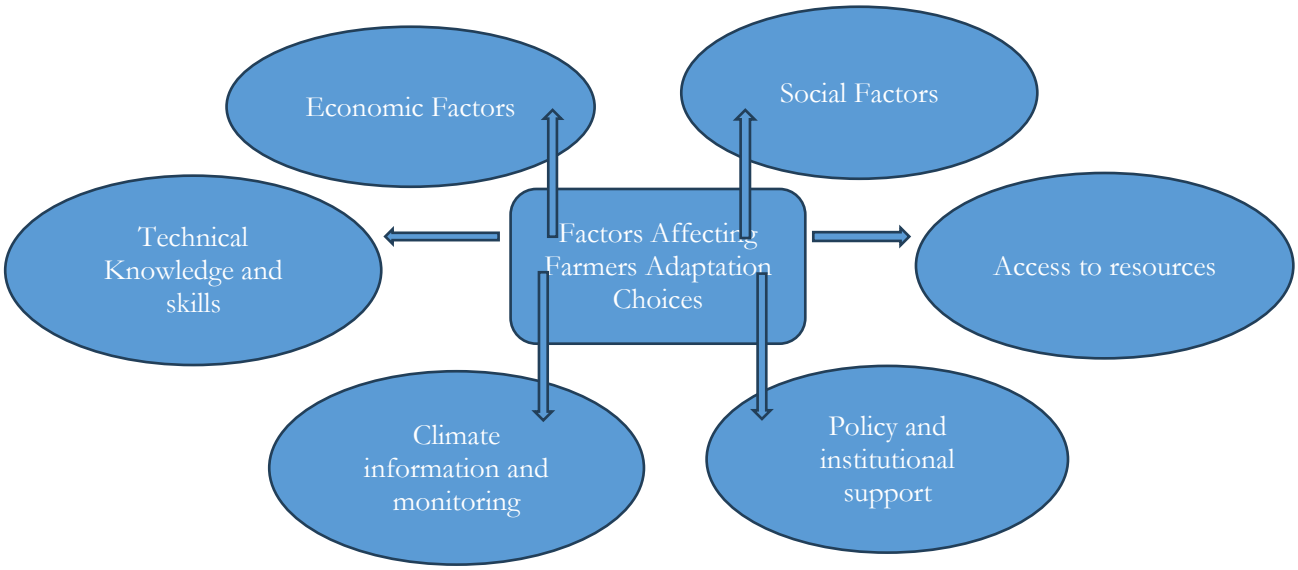

Figure 1. Shows the factors affecting farmers adaptation.
Source: Adaptation Planning.

How Do Dairy Farmers Face The Major Climate-Related Challenges in Fiji

Table 1. Shows dairy farmers fac the major climate related challenges.

Climate-related challenges	Impacts on Dairy Farmers
Temperature Increases	Rising temperatures can reduce milk production and quality, also affecting the health and productivity of dairy cattle. As temperature increases, milk production eventually will decrease because of cattle grazing decreases.
Rainfall Variability	Changes in rainfall patterns lead to severe droughts or floods, impacting milk production, feed availability, and water resources for dairy farming.
Increased Pests and Disease Pressure	Climate change alters the distribution and prevalence of pests and diseases that affect dairy cattle, for example, ticks, lice, and mastitis-causing bacteria. Mastitis is common in cattle milk glands and causes low to no milk production.

Changes in Pasture Quality	Shifts in temperature and rainfall patterns can alter the quality and availability of pastures, affecting the nutritional value of feed for dairy cattle.
Sea Level Rise and Coastal Erosion	Dairy farms near coastal areas may be affected by sea level rise, saltwater intrusion into freshwater sources, and coastal erosion. More soil erosion causes less green grass available for grazing from which the cattle and other animals are affected.

Source: Challenges Faces by Dairy Farmers in Fiji.

How Do Dairy Farmers in Fiji Adopt Adaptation Strategies to Cope With Climate-Related Challenges

Dairy farmers face and go through many climate-related challenges, yet at some point, they must adopt adaptation strategies so that they can have they can combat climatic conditions and continue with dairy farming. Firstly, harvesting of rainwater as many farmers use and install rainwater harvesting systems to collect and store and can be used during dry periods (SPC, 2020). This practice reduces their reliance on groundwater and surface water sources. Irrigation system is another way to conserve water, and which also allows to reduce evapotranspiration (FAO, 2019). Dairy farmers have implemented and adopted irrigation systems way back such as practicing drip irrigation systems. Managing feed is an adaptation system practiced by dairy farmers where they use alternative feed sources like crop residues and by-products which help reduce the impact of feed shortages (FAO, 2019).

Secondly, according to (FAO, 2019), dairy farmers widely adopt breeding for climate resilience. The breeders select dairy cattle breeds that are better adapted to changing climate conditions in Fiji for instance high temperature and heat-tolerant breeds. Dairy farmers also plan for their farm such as farm conditions during severe rain and they walk accordingly and stay prepared for the future. They develop detailed plans as well as contingency plans to anticipate and then respond to climate-related events (SPC, 2020). Managing livestock is sometimes difficult for dairy farmers in Fiji but adopting it helps them practice good livestock management. For example, providing the livestock, mostly cattle, with adequate shade and shelter when they are producing milk or about to give birth. These practices mitigate the impact of heat stress.

Thirdly, market diversification, dairy farmers diversify their markets to sell their products in the new market through many different channels. They use many different markets and explore their products which helps reduce their dependency on a single market (SPC, 2020). Finally, the climate information services, many farmers, whether new or traditional dairy farmers have some knowledge and information about climate and its conditions such as predicting weather. These small decisions have always helped them to stay prepared for upcoming weather events and what dairy farming practices are suitable for the current weather conditions they have predicted. The above-discussed adaptation methods have helped dairy farmers keep moving with their farming practices to date in Fiji (FAO, 2019).

Factors Influence the Choices Made by Dairy Farmers in Fiji for Adapting to Climate Change Temperature and Rainfall Variability

Variable rainfall patterns and high temperatures characterize the tropical climate in Fiji. A rise in temperature and change in precipitation patterns severely affect milk production, water availability, and feed production. This pressurizes farmers to adapt to their management practices.

According to (Thornton, 2009) increased rainfall can hurt livestock through the effect of muddy enclosures and fields on animal mobility. The promotion of waterborne diseases and pests such as armyworms. The reduction in feed availability and quality through the flooding of pastures and the spoilage of stored feed.

Variations in the rainfall patterns can have a devasting impact on livestock production such as effects on field animal mobility through muddy enclosures, more rapid spread of waterborne diseases and pests (worms), and high decline in the availability of feed products through flooding which causes wastage of feed that are stored. Not only this but also road access, machines and farm structures are widely affected by severe rainfall which leads to flooding. Uncooperatively, if there is a reduced amount of annual rain, then the quantity of stocked drinking water and feed can vastly decline. In areas where the growing season length is shortened due to rainfall distribution changes, many animal species can suffer an extended period length of water and nutritional stress.

Thus, animals will have to search for feed and adapt to fewer water frequencies (Thornton, 2009). As the rainfall patterns change frequently or become more variable, the plant tissues lignify increasingly, possess declined digestibility (Giridhar, 2015), and alterations in the food composition towards less palatable species (da Silveira Pontes, 2015). These changes can cause shifts in land use that can comprise unfavorable animal forage compositions, enhancing difficulties for smallholders to control and manage deficits in animal feeds

during the dry season. The variations in rainfall patterns also lead to the death of the livestock species (Thornton, 2014).

Extreme Events (Tropical Cyclone/Water Scarcity)

"Cyclones, droughts, floods, heat waves and other extreme events such as tsunamis and storm surges can lead to reduced production, injury and the death of livestock" (Hoberg, 2008). [Over the past years, many livestock farmers have observed numerous effects of cyclones, heat waves, droughts, storm surges, and flooding which has caused a wide reduction in their livestock production through injury or even death of livestock during flooding, drought, and cyclone periods]. According to (Hoberg, 2008) "the effects can be either direct, such as damage caused by falling trees and moving debris or through the drowning of animals in flooded areas, or indirect through impacts on feed and water quality and quantity" [these effects are caused either by direct damages like moving debris and falling of trees or drowning of livestock animals in areas where flooding occurs rapidly or through indirect effects on the quality of water and feed].

"Flooding can impede access to available pasture and if it persists, will eventually damage or kill inundated pasture. High winds and flooding can also damage management infrastructure such as roads, fencing, wells, feeding stalls, etc. which can all have a detrimental effect on livestock production" (Hoberg, 2008). [In terms of flooding, it can rapidly reduce the access of pasture availability and if this scenario persists, then flooding can even kill deluged pastures.

High winds during cyclones and flooding can also damage infrastructural management like fences, roads, feeding stalls, and so on, which eventually can have harmful effects on livestock production and productivity]. Flood occurrence can also lead to waterborne disease not only in livestock but also in humans as well (Hoberg, 2008).

Tropical Cyclones and Wind Speeds That Happened in the Most Intense Tropical Cyclones

Graph 1. (a) Number of Tropical Cyclones and (b) wind speeds that occurred during intense cyclones in the portrayed years.

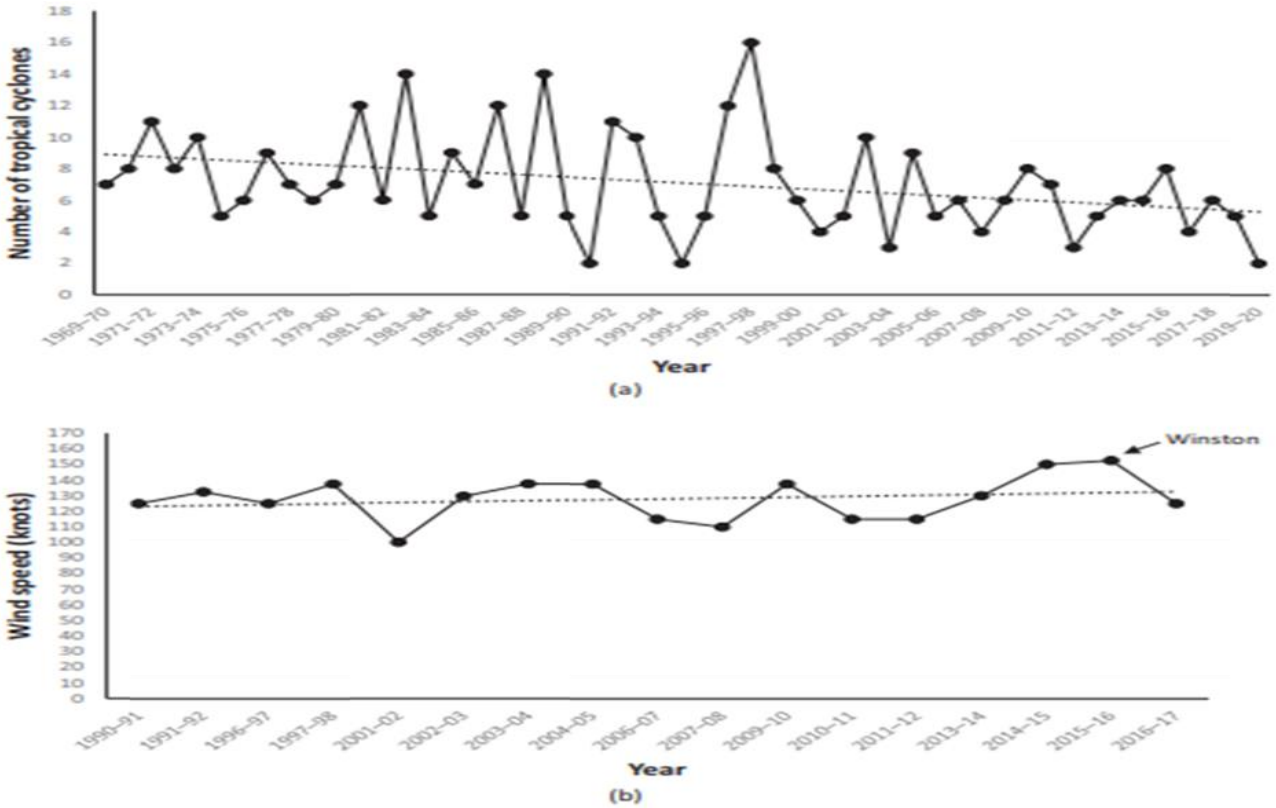

Figure 2. Impact of climate change on sustainable livestock production and existence of wildlife and marine species in the South Pacific Island Countries.
Source: Impact of climate change.

Climate Change on Milk Production

In Fiji, the composition of milk consumption was about 74,430,000 liters annually, yet only 16 percent was met by local production in terms of demand by consumers. Fiji's milk production has been declining year by year due to extreme climatic changes. Thus, farmers face various difficulties in adapting to climate change

such as low quality and quantity of pasture, increased feed costs, low prices on milk, higher mortality rate, irregularity in farm services, increased milk spoilage, and problems associated with the land tenure department.

According to (Lakhan, 2011)"The cost of molasses has increased 58% in the past year. The cost of producing butter has increased 60% in the past 2 years, white life 17% and blue life 33%. While there have been increases in wholesale prices, suppliers are still paid $0.55/liter since 2006". [According to the record and observations done in Fiji, the molasses costs have boosted 58% from past years; butter production has increased by 60%, blue life by 33%, and white life by 17% respectively].

Even though wholesale prices have increased, the farmers and suppliers pay to remain the same from 2006, that is, $0.55/liter]. There has not been specific data regarding the amount paid to the dairy suppliers, however, the CEO of Fiji Cooperative Dairy Company Limited (FCCL), Mr. Sachida Nand), mentioned in 2014 an increase in the pay ($1.00/liter) for the farmers (Government., 2014). Similarly, Mr. Ritesh Dass (Permanent Secretary-Ministry of Agriculture) also mentioned increasing the income of dairy and other agricultural farmers (Government., 2021). During summertime, milk production is the lowest and is more susceptible to changes in rainfall, temperature, flood, and hurricane threats. If the ambient temperature increases by even one degree, the production level will rapidly decrease by 2%. Thus, these events if happening for longer periods can gradually decrease milk quantity and quality in upcoming years (Lakhan, 2011).

The below graph shows the quantity of milk produced in Fiji from the year 2009 to 2018.

Quantity of Milk Production in Fiji from the year 2009 to 2018

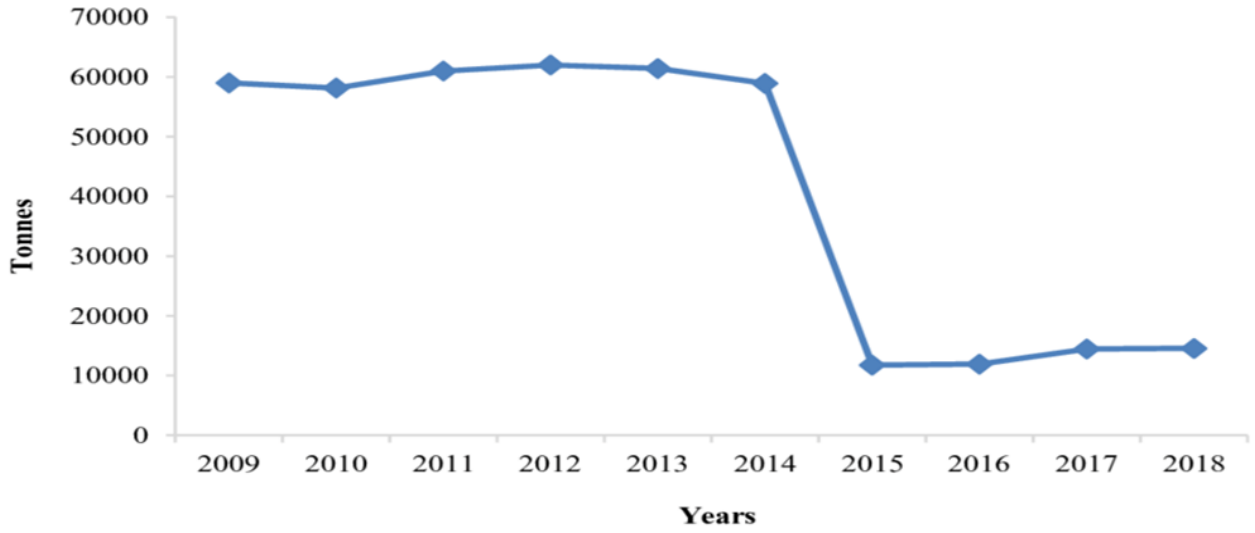

Figure 3. The graph shows the quality of milk production in Fiji from the year 2009 to 2018.
Source: Quantity of Milk Production.

Pest and Disease in Livestock by which Dairy Farmers are Affected

Pests and diseases are also widespread in dairy farming. Dairy farmers have noticed it is because of climate change. Farmers use strategies planning for integrated pest management (IPM) in dairy farming, for instance, using natural predators or biological control agents. The only good role of farm hygiene is to practice preventing disease outbreaks. The climatic conditions have not only affected livestock production but also affected dairy farmers to adapt to climate change through many hardships. Climate change also affects dairy farmers in seasonal and geographical segregation of numerous pests and diseases in their livestock such as cattle. However, dairy farmers have no idea of the occurrence and control methods for those pests and diseases.

Moreover, Mastitis disease in Fiji which highly affects cattle's milk glands, can change its occurrence and infection periods due to climatic changes. Dairy farmers are heavily affected because cattle start to produce milk. According to Balsom (2010), and Igbal (2021), climate can have a direct and indirect influence on mastitis onset. One of the ways climates have an indirect influence on mastitis is that during the wet season, the outside conditions are muddy and, therefore, can cause an increase in the number of mastitis-causing bacteria. As for housing, it influences the chance of getting mastitis, for example, when cattle are outdoors, they have higher chances of getting mastitis whereas, indoor housing can also trigger mastitis when the stalls are small, the cows can get injured and contain mastitis".

Moreover, interpretations made on observed changes in future disease distribution trends have not yet been completely understood by experts. With the above-described climatic changes, the pathogens and hosts can be placed together in a new area, thus deriving new disease and pest threats to animal health and livestock production (Pilling & Hoffmann, 2011). Pathogens that spend half of their life cycle outside the animal host have a high chance of increasing their population due to a rise in the temperature level. Likewise, precipitation and moisture increase in the atmosphere can also lead to better survival for some pathogens, thus, boosting the chances of re-infections in animals which will gradually reduce the production level as well (Harvell et al., 2002).

How Does Climate Change Affect Dairy Farmers and Animal Production

Fiji's Senior Agriculture Officer of Animal Health and Production indicated that the agricultural sector performs a major role in the development of Fiji's economy by contributing around 15% to the total GDP, from which 5% comes from livestock production. This livestock sector involves essentialities for food security, economic development, and employment creation, thus leading to higher foreign exchange earnings.

However, due to changes in the climatic conditions, Fiji has been experiencing many fluctuations in the livestock industry, such as breed and milk production (SPC, 2011). As of last year (2021), the total GDP derived from the agricultural sector in Fiji is 10.4% which depicts the adverse effects of climate change leading to lower agricultural production and economy (Fiji-Country Commercial Guide, Agriculture Sector, 2021). According to (Mary et al. 2016), "The threats to agricultural production from climate change arise largely from changes in temperature and precipitation and intensity of extreme weather events.

These extreme events are likely to be more damaging, especially if their timing coincides with a crucial developmental stage in the life cycle of a living organism". [Climate change extortions to agricultural (crop and livestock sector) and fisheries production occur vastly from both temperature and precipitation alterations, as well as extreme weather change events. These extreme weather conditions can be more devastating if they coincide in their time of occurrence with the critical stages of development in the life cycle of an organism], like livestock species. Sometimes it is hard for the animal species to recover from these kinds of adverse effects, as well as sometimes, the effect recovery is so difficult that species are not able to adapt, and another wave of extreme weather conditions occurs again leading to more devastation and extinction of animal species]. A model was used by Pacific organizations namely Climate Model Intercomparison Project 3 (CMIP 3) to interpret the future consequences of extreme climatic changes, that is, rise in sea level, temperature change, and many more.

How Does Climate Change Affect Animal Behavior and Dairy Farmers

Behavioral traits of animal species are one of the most important elements regarding their strength against climatic changes and most farmers are affected by those changes. Biologists have agreed upon the animal behavioral responses to the alterations in the climatic conditions which will determine factors assuming the susceptibility of animal species towards climatic threats to biodiversity (Huey, 2012). However, records show little information about animal responses to extreme weather events and variations. An inherent study on the nature of animal behavior is applicable for tackling the complex task of understanding animal diversity response to the changes in climatic conditions and evaluating effective solutions (Buchholz, 2007).

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An inherent study on the nature of animal behavior is applicable for tackling the complex task of understanding animal diversity response to the changes in climatic conditions and evaluating effective solutions (Buchholz, 2007). Numerous animals have already optimized their evolutionary traits through physiological strategies and adapted behaviors to adverse climate changes that will occur over their lifetimes. Animals may be able to depend on their resilience strategies that were previously selected, that is, adaptive phenotypic plasticity, which will help them to face the weather changes. According to (Snell-Rood, 2013), plasticity is classified as development and activation classes, conceding that behavioral performances may relate to aspects of both classes. The behavioral plasticity under the activation class is called flexibility (Swaddle, 2016), which permits various neural network activations that still exist in different environmental situations. Whereas behavioral plasticity is simply regarded as plasticity only, the output of current behavioral situations has been constrained by experiences in ontogenetic developments.

The below figure shows the animal population's abilities to persist in futuristic climatic changes depending on variations in their behavior such as plasticity, flexibility, genetic variation, and evolutionary

history. In the above figure, the ground squirrel seemed to shade itself from solar radiation by using its bushy tails as the air temperature increased. (a-b) shows behavioral changes, *i.e.*, situating its tail to the back to appear larger to predatory which will help it to survive warming conditions. (b-d) shows that the adaptation can also be sufficient for them to even survive in hotter conditions.

However, (b-e) depicts that it might be insufficient for warming conditions which will lead to lower recruitment of the population or even may lead to the extinction of that population (b-c). (f) Shows variations in the genes that provide the capability to genetic adaptations to increased warming temperatures. (f-b); evolutionary rescue), yet variation exhaustion because of direct selection can still result in extinction (f, b, c). (i) Animal plasticity responding to climate changes may force populations to resist neg**a**tive effects of warming conditions (i-j) that can (d, e) or cannot (c) ensure the viability of the population over a long period.

The shaded umbrella in (g) depicts populations evolving slowly over time when the heritable response to the selection of genotype is low and the climatic change rates are high. The shaded umbrella also helps to evolve successfully to a phenotype that can survive hotter climates in the future (g-d, e), or else conservation methods will be needed to continue (g and j, to h). Plastic responses to the warmer environment being indistinguishable from the genetic fixation (b) will be very hard to respond to warmer climates (j).

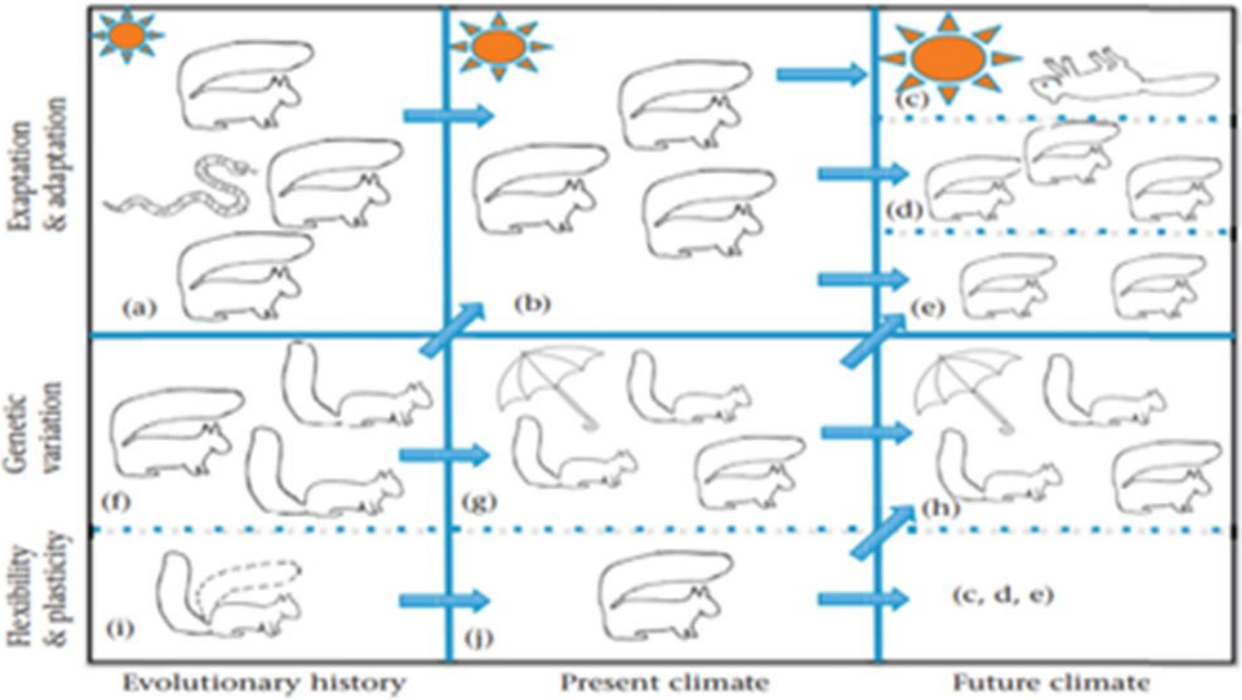

Figure 4. Behavioral research priorities for studying animal response to climate change
Source: Animal Behavior showing persistence to future climatic conditions

Challenges and Opportunities Faced by Dairy Farmers in Fiji in Adapting to Climate Change

Table 2. Challenges and Opportunities Faced by Dairy Farmers in Adapting to Climate Change

Challenges	**Opportunities**
Limited access to financing for adaptation projects.	We are strengthening the Fiji dairy industry's capacity for climate resilience.
Limited awareness and information are provided about climate change impacts and adaptation options.	We are improving access to finance and credit for adaptation projects.
Insufficient infrastructure for irrigation and water storage provided for future storage of water.	We are developing climate-resilient breeds and crop varieties.
Limited availability of climate-resilient breeds and noticing that not all livestock are used to staying out all day, all need shade and water at any time of the day.	Enhancing extension services and advisory support for farmers.
Limited extension services and awareness programs about dairying.	Encouraging policy support for sustainable dairy industry, marine, and agriculture practices.

Source: Challenges and Opportunities.

The table above shows the challenges and opportunities faced by dairy farmers in Fiji in adapting to climate change. Clearly, it shows that there are many challenges for farmers to go through, and adapting to climate change is the best way for them to go forward. Since dairy farming is one of the contributors to Fiji's economy, therefore dairy farmers also get some opportunities from the Government and other NGOs for the smooth running of the industry.

The Government's Comprehensive Approach to Support Dairy Farmers in Fiji Adapting to Climate Change

Figure 5. The diagram shows the Government's Comprehensive Approach to Support Dairy Framers in Fiji Adapting to Climate Change.
Source: Comprehensive Approach to Support Dairy Farmers in Fiji Adapting to Climate Change.

The above is the government's and other relevant NGOs' approaches to supporting dairy farmers in Fiji to climate change. The initiatives they provide to dairy farmers are helpful for them as well as the dairy farmers themselves. These initiatives have a positive effect on the dairy farmers that they are being supported by their government and they work harder in accepting and adapting to the climate change and mitigation measures and continue with dairy farming despite the many challenges they face.

CONCLUSIONS

In conclusion, dairy farming is a significant sector of Fiji that many local populations rely on for daily consumption such as milk, cheese, and yogurt. It is also an important contributor to the Country's economy. However, the main factor that influences the dairy industry/farming is climate change. All dairy farmers and the dairy industry face difficulties surviving and must adapt to all upcoming changes to make the dairy industry work. Climate change also poses a significant threat to the dairy industry's sustainability with heat stress in livestock mostly in cattle, rise in temperature, change in precipitation patterns, and increased frequency of extreme weather events that impact the production of milk and its quality.

To mitigate these risks, dairy farmers in Fiji must adapt to changing climatic conditions. It has been observed and noticed that dairy farmers in Fiji are already taking steps to adapt to climate change such as improved water management. For instance, dairy farmers adopt irrigation systems to manage water resources and reduce the impact of droughts. Breeding climate-resilient cattle, some dairy farmers select breeding cattle breeds that are better suited to the changing climatic conditions in Fiji. Managing heat stress,

dairy farmers use shade or ventilation to mitigate the heat stress in livestock such as cattle during hot conditions.

Lastly, the adaptation plan looks promising, which can further support and help dairy farmers in Fiji. For instance, climatic information services provide dairy farmers with accurate information that can help them to make their decisions about dairying, and other farm activities. Technical assistance can be provided such as training programs that can help dairy farmers to adopt new technologies and improve resilience to climate change. Important incentives for climate-resilient practices can be helpful for the government and donors to dairy farmers, such as providing incentives for dairy farmers to adopt climate-resilient practices such as subsidies during severe flood and drought conditions. Finally, research and development, more research and awareness can be done for all dairy farmers to understand new technologies. This can help dairy farmers in Fiji adapt to the changing climate.

RECOMMENDATIONS

Climate change adaptive measures are essential to manage the causes of various climatic conditions and to protect the most vulnerable and poor from an unduly high burden, most importantly the dairy farmers of Fiji. However, the cost of performing manageable methods is challenging due to the uncertainties of climate change. Nonetheless, estimations done for adaptation costs give useful information to support decision-makers (organizers, stakeholders, government) in Fiji in scheming their adaptive strategies with guidelines to help and support almost all the communities and individuals. The Fijian Government, through a task team comprised of experts from NGOs, government agencies, and private sectors, whereby, they were designed to provide national communication reports to UNFCCC in 1998. The national communication report involves the vulnerability of the Pacific to climate change and a nation's capacity for adaptation to adverse effects of climatic conditions.

Countries in the Pacific including Fiji supported By FAO came up with approaches for adaptative measurements in the agricultural sector for developing schemes against climatic changes. This approach suggested by FAO is to emphasize "Research and Extension of Flexible Farming Systems that will be Tolerant to Climatic Stress and Variability". Systems like this should be part of a comprehensive and interspersed approach, which will obtain various and multiple inter-dependencies, that is, between the water and land resources, coastal areas, and the interaction of humans with these resources. However, these strategies must be rational with national terms and policies, especially those strategies that involve environmental management and community participation.

The strategies placed by FAO for Fiji were as follows: (1) Establishing Commodity Development Framework (CDF) which will aim to boost the economic growth of subsistence communities in Fiji. (2) Prepare a policy for draft land use in Fiji, which will include suggestions and recommendations aimed at imperishable management of the land resources in Fiji. (3) Merging research and extension divisions will help and provide better opportunities for research in the farming system. (4) The CDF program introduced in the Land-use Planning Section to derive sustainable practices for land use, specifically in sloping land areas that are prone to erosion. (5) Establishing a Geographical Information System, within the planning section of the Land-use Program, aiming to provide correct information on crops that would suit which type of soil and climatic conditions. The strategies mentioned above could be enhanced further by putting a much stronger emphasis on decreasing the effects of extreme climatic changes. The 1997/1998 El Nino drought has created a high awareness of putting these strategies into action. Likewise, the communities are encouraged to make decisions and choices that will be for the betterment of their livelihoods. However, this brings multiple challenges, since different commodities possess different perceptions and give various feedback regarding the climatic changes that are happening. Not only this, but communities also give information on old risks, for instance, poverty, development, and environmental degradation, thus, increasing the difficulties in providing them with more extension and research services. There have been many indications suggesting that there are groundwater reserves in the West. However, the benefits of getting water from these reserves should meet the costs of irrigation scheme establishment.

Adding on, the possibility of reduced income return from crop production has become a need that needs to be considered. Better land areas that are suitable for selected crops could help in obtaining higher-value crops like sugarcane and root crops (dalo, cassava). This situation is still being assessed due to uncertainty over land leases. Due to the possibility of El Nino Drought striking again in Fiji and damaging not only root crops but other vegetation as well, higher, and better adaptation capabilities have been considered for crops, whereby, land management strategies will be developed to put accurate costs for drought-proofed selected crops. Thus, this will help in growing plants that are more tolerant to drought events happening in Fiji, which will eventually lead to a vast increment in the agricultural sector. In this manner, there is a need to

implement strategies on extreme climatic conditions that are changing rapidly, so that Fiji's agricultural sector including crops and livestock as well as industrial and tourism sectors could be protected from the upcoming climatic changes.

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