International Journal of Environment and Climate Change

11(7): 68-79, 2021; Article no.IJECC.72458
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Innovation Diffusion in the Utilization of Fish Resources in Bangourain, West Region of Cameroon: Environmental Impact and Sustainability

Jude Ndzifon Kimengsi[1*], Desmond Forbah Tafuh[2] and Sunday Shende Kometa[2]

[1]Department of Geography, The University of Bamenda, Cameroon.
[2]Department of Geography and Planning, The University of Bamenda, P.O. Box 39, Bamenda, Cameroon.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2021/v11i730441
Editor(s):
(1) Dr. Fang Xiang, University of International and Business Economics, China.
Reviewers:
(1) Sushan Chowhan, Bangladesh.
(2) Md. Saikat Hossain Bhuiyan, Bangladesh.
(3) Shamima Islam, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72458

Original Research Article

Received 20 June 2021
Accepted 31 August 2021
Published 04 September 2021

ABSTRACT

Fish is considered a crucial resource for the sustenance of livelihoods in water-dependent communities across the globe. However, geographical studies on innovations in the use of this resource are limited in the Cameroonian context. This study investigates the pattern of innovation diffusion in the utilization of fish resources, drawing from a random sample of 106 fishing households in Bangourain. The multiple linear regression analysis revealed that a single unit change in the natural drivers of innovation triggers a 0.164 change in the spatial diffusion of innovation in the utilization of fish resources (p-value > 0.05). With regards to the economic and cultural drivers of innovation, a unit change in their values lead respectively to a 0.538 and 0.424 shift in the diffusion of innovation. The results suggest that while the economic and cultural drivers of innovation are significant (P < 0.05), those of natural drivers are insignificant (P > 0.05). Policy interventions should leverage natural attributes to foster the effective diffusion of innovations – focusing on the tools and methods applied in fish harvesting.

**Corresponding author: E-mail: jude.kimengsi@catuc.org;*

Keywords: Innovation; fish resources; drivers; Bangourain; livelihoods; innovation; rural development; Cameroon.

1. INTRODUCTION

Fish resources are vital for the survival of humanity across the globe. Conflicts linked to the protection of aquatic resources and fish exploitation have witnessed an increase. This is partly explained by the lack of dialogue between stakeholders representing these two interests [1] [2]. However, despite the increasing recognition of this resource unit, innovation defects persist [3]. The adoption of innovations by fishing communities depend on factors specific to both individuals and their social contexts [4]. Fish farmers sought to adopt technologies that are perceived to be advantageous in terms of productivity, cost efficiency, and the ease of management [5]. Innovation adoption decisions are complex; the factors militating for or against such processes have been established in agro-based systems, with very limited evidence on innovation patterns in the utilization of fish resources [6]. Innovations exist in the utilization of fish resources in Africa, albeit fragmented [7]. However, in areas such as Zimbabwe, fish farming as an innovation was well embraced by local communities as it led to improvements in food security, household income and employment generation [8]. Technologies in the utilization of fish resources need to be managed from changes in fish capture to fish handling; this also entails the need to ensure that evolving fishing technology is more proactive than reactive [9]. The trends and priority changes for fishery technology inventions vary across societies [10]. The situation in Kenya shows that 30% of fish farmers were categorized as high adopters of novel aquaculture technologies, implying that there are gaps in technical skills hindering the adoption of innovative technologies [11]. In Cameroon and particularly in Bangourain, the potentials for innovation diffusion in the utilization of fish resources seem to require a positive perception of new innovations and sound policies at the national level. The population of Cameroon's demand for fish resources is estimated at more than 400,000 tons. Yet, production is still insufficient to meet this demand and the contribution of fisheries and aquaculture is less than 1% of Gross Domestic Products (GDP) [12]. The Bangourain community hosts significant fish resources. With the creation of the Bamendjim reservoir in 1974, the area became an important fish resource site. This led to the introduction of new methods of fishing with changes in fishing equipment's such as bamboo canoe to plank canoe, the use of basket trap to iron trap and the cast net trap, among others. Several studies have explored natural resource development in Cameroon [13] [14] [15] water resource exploitation [16], and the natural resource development paradox [17] However, scientific evidence on the pattern of innovations and their diffusion in fishery resource development are lacking. Put succinctly, the extent to which such innovations spatially diffuse remain unknown. This paper sought to explore the pattern and drivers of innovation diffusion in the utilization of fish resources in Bangourain.

2. MATERIALS AND METHODS

2.1 Study Area

Bangourain community is located between latitude $5^{o}5'$ North of the equator and longitude $11^{o}13'$ East of the Greenwich Meridian (Fig. 1). It is located some 35km from Foumban in the West Region of Cameroon [18]. Bangourain shares boundaries with Jakiri sub division to the North, Foumban sub division to the South and Galim and Babessi Sub divisions to the West. The area covers eight villages which include Bangourain, Bangambi, Kourom, Kouhouat, Koumengba, Koumbam, Koupoukam I and Koupoukam II. Three of these villages possess significant fish resources, they include Bangourain, Kouhouat and Koumengba.

2.2 Data Collection

The study made use of simple random sampling technique to select the 106 fishermen (Table 1) involved in the utilization of fish resources. The main instrument developed for data collection was structured a questionnaire to fishermen in Bangourain. Both qualitative and quantitative data came from this main tool of data collection.

Interviews were conducted with resource persons from Bangourain Sub Divisional Delegation (BSDD) of Ministry of Livestock and Fisheries (MINEPIA) such as the Sub Divisional Delegate and the Chief of Post for fisheries. This was done to examine their role in ensuring innovation diffusion in the utilization of fisheries. Field observation as another tool for data collection was undertaken between 15^{th} of

January to 30th April 2021 which helps in understanding factors that shapes the pattern of innovation diffusion in the utilization of fish resources. It also helps in evaluating the implications of innovation diffusion in the utilization of fish resources. .

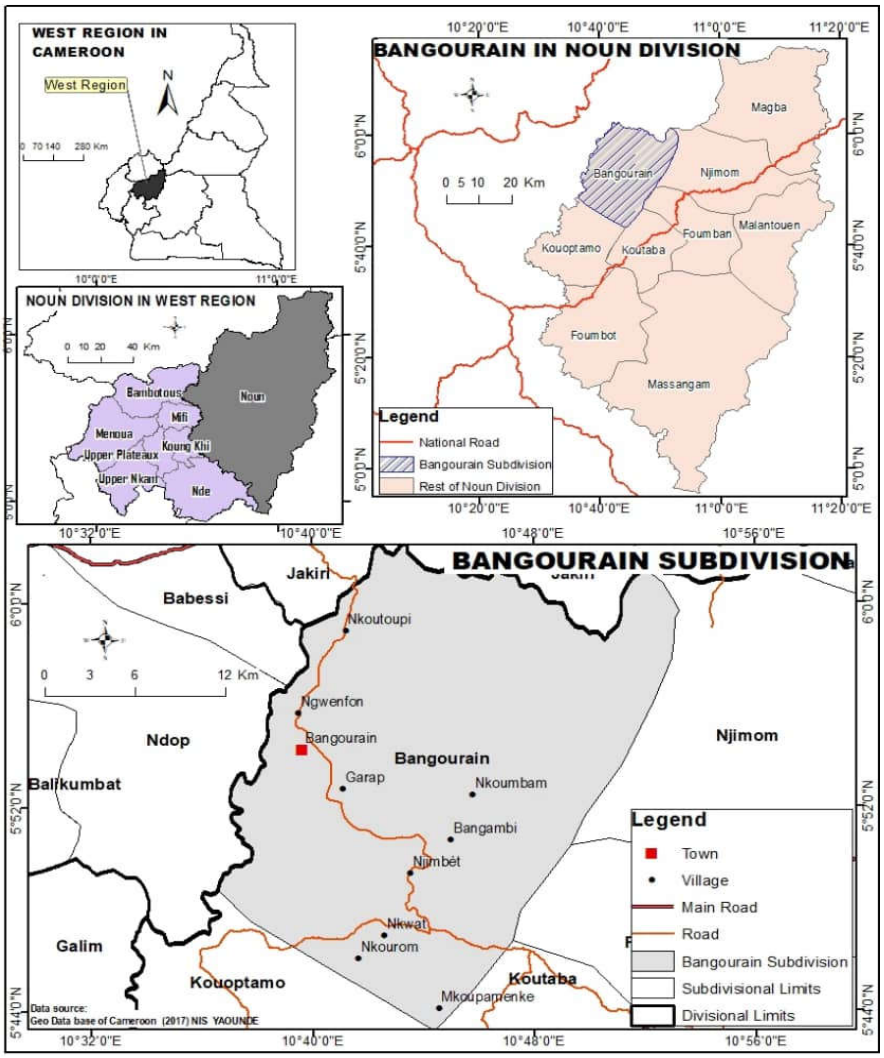


Fig. 1. Location Map of Bangourain Sub Division (Source: National Institute for Statistics, Cameroon)

Table 1. Sample of study communities

Villages	Population (2005)	Population estimate (2021)	Population Actively involved in fishing (10%)	Number of Questionnaires Administered	Number of Questionnaires Retrieved
Bangourain	14582	20648	2064	73	57
Koumengba	3296	4667	467	17	15
Kouhouat	3251	4603	461	16	16
Total Population	21129	29918	2992	106	88

Source: BUCREP, [19]

2.3 Data Analysis

The data collected from the field were analysed using both descriptive and inferential statistical tools. Descriptively, data collected from the field through questionnaires and interview was sorted and computed using statistical package for social sciences vision 21 (SPSS21) and Microsoft Excel 2016 in which the data were treated. The multiple linear regression analysis was performed to analyse the data. The general formula for regression analysis applied in this study is:

$$\hat{Y} = b_o + b_1 X_1 + b_2 X_2 + \ldots b_p X_p$$

Where $\hat{Y}$ = is the predicted or predicted value of the dependent variable,
X_1 through X_p = distinct independent variables,
Bo = the value of Y when all the independent variables are equal to zero and
b_1 through b_p= estimates of regression coefficients
NB. Each regression coefficient represents the amount of change in Y relative to one-unit change in the independent variable.

Specifically, the multiple linear regression was used to evaluate the extent to which natural, economic and cultural drivers account for high probability of spatial diffusion of innovations in the utilization of fish resources in Bangourain Sub Division is thus:

$$NECD= B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + Ei \ldots (e)$$

Where:
NECD= Natural, Economic and Cultural Drivers
X_1= Spatial diffusion of innovations in the utilization of fish resources
X_2= Drivers of Innovation diffusion
X_3= Barrier of Innovation diffusion
X_4= Strategies to improve Innovation diffusion
X_5= Level of Education
Ei= other variables not considered in the model
e= Error

The Durbin-Watson test was run to ensure that the assumption of no auto-correlation was met whereas the ANOVA table of standardised residuals on standardised predicted values were examined to ensure that the assumptions of linearity, homoscedasticity and normal distribution were met.

3. RESULTS AND DISCUSSION

3.1 Innovations in the Utilization of Fish Resources in Bangourain

Bangourain community has inland water bodies which are rich in fish. The main water reservoir in Bangourain is the Bamenjim dam with varieties of fish resources that has been experiencing some innovations in its utilization. Before 1974, the utilization of water resources for fisheries was on a small scale with the practice of traditional fishing methods using traps and the blockage of stream channels during the dry season. Some innovations include the use of nets (gillnets, cast nets, purse seine nets), hooks and lines with the aid of bamboo canoe and plank canoes. Fig. 2 shows innovation trends with respect to the utilization of cast net trap used in Bangourain.

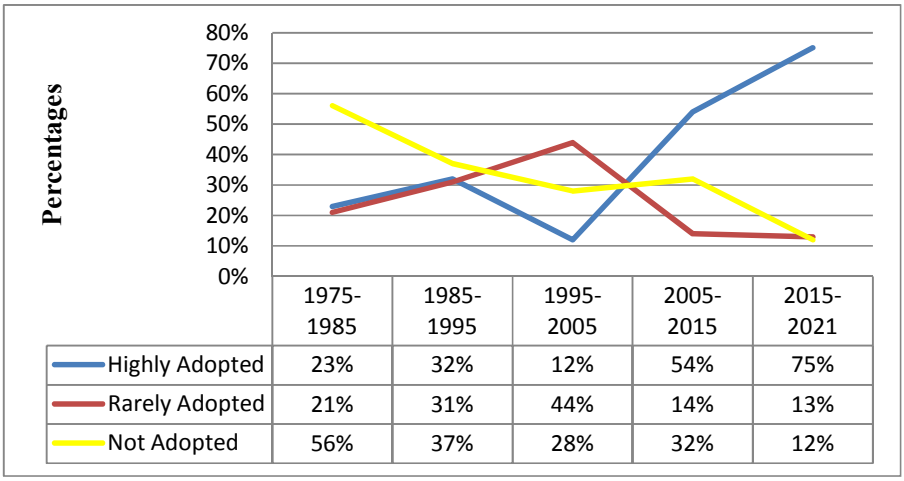
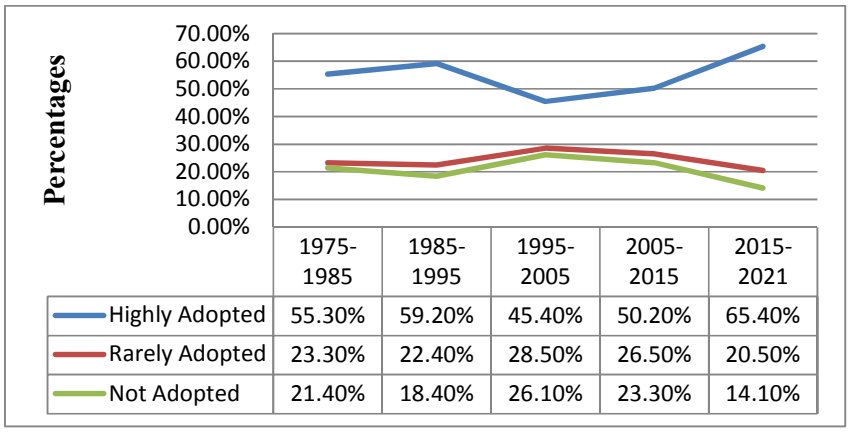


Fig. 2. Innovation trends with respect to the utilization of cast net trap for fishing in Bangourain Sub Division

Fig. 2 shows varying trends in the utilization of cast net trap for fishing in Bangourain. The proportion of fishermen who adopted the use of cast net trap increased since 1975 from 23% to 32% between 1985 and 1995. From 1995 to 2005, it witnessed a decline to 12%. Between 2005 and 2015, this witnessed an increase to 54% while between 2015 and 2020 it increased to 75%. The proportion of fishermen who did not adopt or rarely adopted the use of cast net trap decreased from 56% and 21% respectively in 1975 to 12% and 13% in 2021 respectively. Since 1985 these fishermen have been changing from the use of bamboo canoe to wooden canoe for fishing in Bangourain. Fig. 3 shows innovation trends in the utilization of plank or wooden canoe for fishing in Bangourain.

From Fig. 3, the proportion of fishermen who highly adopted the use of plank canoe for fishing has been increasing since 1975. From 1975 to 1985, it increased from 55.3% to 59.2% between 1985 and 1995. The proportion of fishermen who used wooden canoe from 1995 to 2005 declined by 45.4%. The effectiveness of plank canoe in fishing based on speed made the situation to start changing with an increase of 50.2% from 2005 to 2015 and a high proportion of fishermen between 2015 and 2021 that is 65% adopting to the use of plank canoe to bamboo canoe in Bangourain. The proportion of fishermen who rarely use wooden canoe decrease from 23% in 1975 to 20.5% in 2021 even though the proportion remains small between 1995 and 2005 as it increases to 28.5% and 26.5% between 2005 and 2021. Also, the proportion of fishermen who did not adopt the use of wooden canoe decrease from 21.4% in 1975 to 14.1% in 2021. Fishermen who did not use plank canoe in 1985 to 1995 decreases to 18.4% but between 1995 and 2005 it increases to 26.1% and 23.3% between 2005 and 2015. Fig. 4 shows the use of bamboo and plank canoes for fishing in Bangourain Sub Division.



	1975-1985	1985-1995	1995-2005	2005-2015	2015-2021
Highly Adopted	55.30%	59.20%	45.40%	50.20%	65.40%
Rarely Adopted	23.30%	22.40%	28.50%	26.50%	20.50%
Not Adopted	21.40%	18.40%	26.10%	23.30%	14.10%

Fig. 3. Innovation trends in the utilization of plank canoe for fishing

Fig. 4. The use of bamboo and plank canoes for fishing in Bamendjim reservoir
Source: BSDD of MINEPIA

Periodical or seasonal fishermen practice fishing during the period of low water volume in the dry season except around areas of Kouate and Bangourain. This type of fishermen practice fishing in the area only during the period of January-June when the volume of water in the reservoir is low as they reservoir also supply water to Edea for electricity during this period. During the period of June to December as the reservoir is full of water, seasonal fishermen leave for other activities such as rice cultivation in Bangourain Sub Division. Fig. 5 shows fish species harvested in Bangourain.

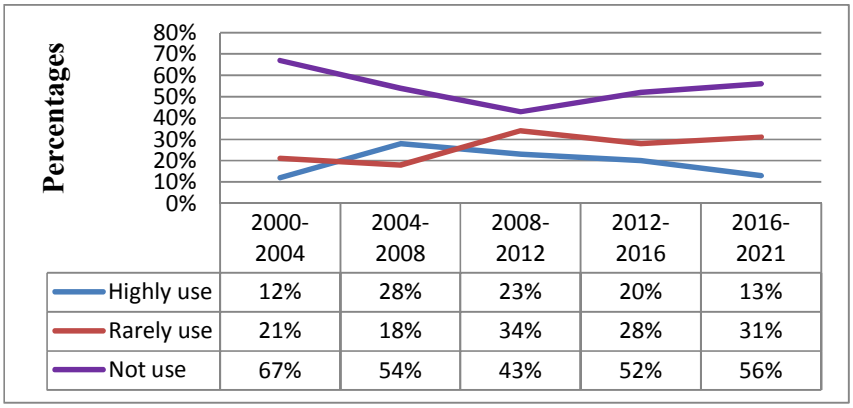
In Bangourain, five different species of fish are common. They include Tilapia spp, Mudfish, Barbus spp., Snake like and Electric cat fish. The area is also made up of three species of lobster namely Crabs, Cray fish and Frogs. In order to effectively manage fish resources, the government introduced the use of three finger nets in the utilization of fish resources. Fig. 6 shows trends in the utilization of three finger nets.

Fig. 6 shows that the proportion of fishermen who did not respect the use of three fingers net in fishing was high between 2000 and 2004; with 67% and 54%. A decrease of 43% was experienced between 2008 and 2012. The situation changed between 2012 and 2016 with an increase from 52% and 56% between 2016 and 2021. The rate of diffusion within the proportion of those who highly use and rarely use three fingers net increased from 12% and 21% in 2000 to 13% and 31% respectively.

3.2 Pattern of Innovation Diffusion in the Utilization of Fish Resources

Before the creation of Bamendjim reservoir in 1974, small scale fishing was practiced in Bangourain. During this period, fishing was dominant during the dry season as the volume of rivers and inland water bodies reduced. The main innovators of inland water resources of fisheries in it utilization from 1960 to 1980 was the natives of Bangourain. After the creation of Bamendjim reservoir, the area became a fishing hub. Fig. 7 shows the flow of innovations diffusion in the utilization of fish resources in Bangourain while Table 2 shows innovations trends in the utilization of fish resources in Bangourain.

Fig. 5. Fish species in Bangourain Sub Division



	2000-2004	2004-2008	2008-2012	2012-2016	2016-2021
Highly use	12%	28%	23%	20%	13%
Rarely use	21%	18%	34%	28%	31%
Not use	67%	54%	43%	52%	56%

Fig. 6. Innovation trends with respect to the utilization of three fingers net in managing fish resources in Bangourain Sub Division

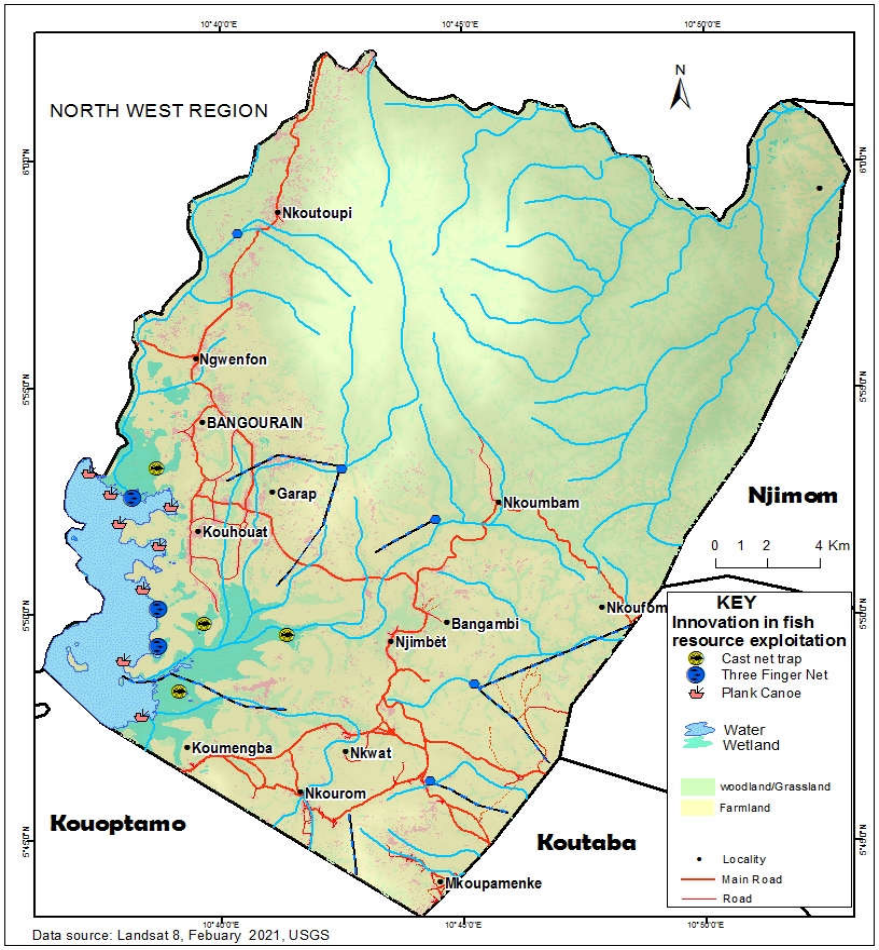


Fig. 7. The flow of innovations diffusion in the utilization of inland water resources of fisheries to Bangourain

Table 2. Innovation trends in the utilization of fish resources in Bangourain

Adoption Period	Fishing Methods	Fishing vessels
1960-1970	Basket trap & fishing trap barrier along a stream channel	Bamboo Canoe
1970-1980	Basket trap, Magic and cotton robe with hooks, Iron trap & Cash net	Bamboo Canoe
1980-1990	Basket trap, Magic and cotton robe with hooks, Iron trap, Cash net trap & Cash net	Bamboo & Plank Canoe
1990-2000	Basket trap, Magic and cotton robe with hooks, Iron trap, Cash net trap, Cash net and Gill nets of 1 finger	Bamboo & Plank Canoe
2000-2010	Magic and cotton robe with hooks, Iron trap, Cash net trap, Cash net and Gill nets of 1& 2 finger	Bamboo & Plank Canoe
2010-2021	Magic and cotton robe with hooks, Iron trap, Cash net trap, Cash net and Gill nets of 1, 2 & 3 finger	Bamboo & Plank Canoe

From 1980 to 2021 fishing methods have changed from Basket trap & fishing trap barrier along a stream channel to Magic and cotton robe with hooks, Iron trap, Cash net trap, Cash net and Gill nets. Fig. 8 shows the different adoption periods of innovations in the utilization of fish resources.

Fig. 8 shows that from 1975 to 1985, the rate of innovation diffusion in the utilization of inland

water resources was high with about 25% of the fishermen using new fishing equipment. The increase in innovation diffusion was due to the creation of the Bamendjim reservoir in 1974 that led to an increase in water volume a. This increase continued from 1985 to 1995 to about 29.55% and this was due to the economic crisis of 1985. Again, between 1995 and 2005, the rate of innovation diffusion started witnessing a decline by about 18.18% From 2015 to 2020, the rate of diffusion increases to 15.91% as a result of continuous sensitisation of fishermen on the importance of the new technology of three finger nets in Bangourain.

3.3 Drivers of Innovation Diffusion in the Utilization of Fish Resources

Innovation diffusion in the utilization of inland water resources of fisheries is based on different fishing methods and fishing equipment that was brought from Magba by other fishermen as well as those that are being put in place by MINEPIA in Bangourain Sub Division. Findings shows that as a result of increase in the number of fishermen in Magba, some of the fishermen moves to the inland water of Bamendjim reservoir in Bangourain Sub Division for fishing since the area was a new ground for fishing and rich with fish resources. These new fishermen came with new techniques in fishing and the output of fish cash was encouraging to them as compare to their previous fishing areas in Magba and Lake Chad basin. The transfer of fishing technology from Magba to Bangourain Sub Division spread rapidly because of the effectiveness of the new fishing technology in harvesting fish resources. Table 3 shows the drivers of innovation diffusion in the utilization of inland water resources in Bangourain.

With the introduction of cast net traps and cast net of different sizes, fishermen that adopted the new technology testify that their quantity of fish catch per day increased as compared to the use of basket and iron traps. This account for 70.5% of fishermen to agree that availability of fish resources and effectiveness of new fishing technology makes them to communicate other fishermen about new the technology while 29.5% of the fishermen disagree that they spread the new technology because of availability of fish resources and effectiveness of new fishing techniques. Also, 65.9% of the fishermen agreed that through the transfer of new fishing methods from Magba by Kotoko fishermen the technology spread as the fishermen makes friends with the old fishermen in Bangourain Sub Division. Again, 62.5% of the fishermen agreed that with their community life style in Bangourain Sub Division, they spread the advantages of these new technologies to their brothers while 37.5% disagree. Similarly, in Bangourain Sub Division 68.1% of the fishermen agree that increase in income as a result of new fishing methods plays an important role in spatial diffusion of new fishing methods while 31.9% of the fishermen disagreed. Lastly, 67.1% of the fishermen agreed that sensitisation of the population about new fishing technology by the chief of post for fisheries in Bangourain helps in spreading the technology while 22.9% of the fishermen disagreed. The multiple linear regression analysis was used to show the contribution of natural, economic and cultural drivers on spatial diffusion of innovations in the utilization of fish resources in Bangourain Sub Division. Model summary, ANOVA and coefficients of the multiple linear regression analysis was run in SPSS to test the effect of natural, economic and cultural drivers on spatial diffusion of innovations in the utilization of fish resources in Bangourain Sub Division. Table 4 shows the model summary of the effects of natural, economic and cultural drivers on spatial diffusion of innovations in the utilization of fish resources in Bangourain.

Based on Table 4 natural, economic and cultural drivers of innovation are responsible for 75.4% (R^2 = 0.754) of spatial diffusion of innovations in the utilization of fish resources. This means that other factors not included in the investigation jointly account for 24.6% variance in spatial diffusion of innovations in the utilization of fish resources in Bangourain. The table again shows that the result can be generalised to the population from which the sample was taken since the variance between R^2 and adjusted R^2 is just 0.009. Table 5 shows natural, economic and cultural drivers of innovation and spatial diffusion of innovations in the utilization of fish resources in Bangourain.

Table 5 shows that using a simultaneous entry multiple linear regression, there was a significant model (*F = 85.643, df = 3, p = 0.000*) for the relationship between ratings of natural, economic and cultural drivers of innovation and spatial diffusion of innovations in the utilization of fish resources in Bangourain. The P-value of less than 0.05 implies that at 3 degree of freedom, the model reached significant level in predicting the outcome variable. Where ANOVA is equal to Analysis of variance and F is variance ratio while

Df is the degree of freedom as well as P is the probability value. Table 6 show relative coefficients (contributions) of natural, economic and cultural drivers on spatial diffusion of innovations in the utilization of fish resources in Bangourain.

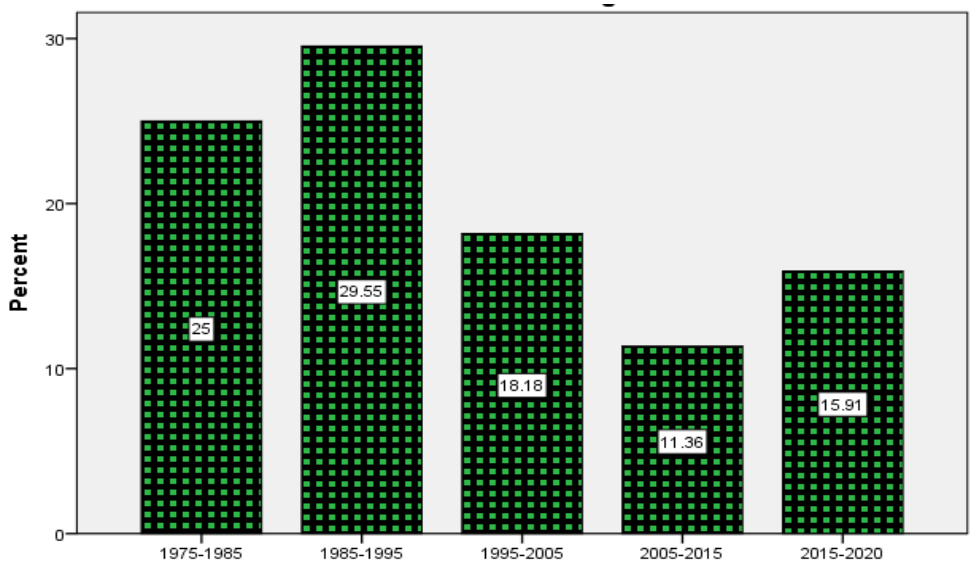


Fig. 8. Adoption period of innovations in the utilization of Inland water resources of fisheries using new fishing equipment of plank canoe in Bangourain

Table 3. Drivers of innovation diffusion in the utilization of inland water resources of fisheries in Bangourain

Innovators and Adopters perception	Category	Frequency	Percentages	Total %
Availability of fish resources and effectiveness of new fishing techniques	SA	51	58.0	
	A	11	12.5	70.5
	D	16	18.1	29.5
	SD	10	11.4	
	Total	88	100.0	**100**
Transfer of new fishing methods from Magba	SA	31	35.2	
	A	27	30.7	65.9
	D	24	27.3	34.1
	SD	6	6.8	
	Total	88	100.0	**100**
Community Life style in spreading information	SA	38	43.2	
	A	17	19.3	62.5
	D	17	19.3	37.5
	SD	16	18.2	
	Total	88	100.0	**100**
Increase in income as a result of new fishing methods	SA	42	47.7	
	A	18	20.4	68.1
	D	22	25.1	31.9
	SD	6	6.8	
	Total	88	100.0	**100**
Sensitisation of the population about new fishing technology	SA	46	52.3	
	A	13	14.8	67.1
	D	20	22.8	22.9
	SD	9	10.1	
	Total	88	100.0	**100**

Table 4. Model Summary of natural, economic and cultural drivers of spatial diffusion of innovations in the utilization of fish resources

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			Durbin-Watson
					R Square Change	F Change	Sig. F Change	
1	.868[a]	.754	.745	.70273	.754	85.643	.000	2.289

a. Predictors: (Constant), Natural, Economic and Cultural Drivers of Innovation
b. Dependent Variable: Spatial Diffusion of innovations in the utilization of fish resources

Computed using SPSS version 21

Table 5. ANOVA for spatial diffusion of innovations in the utilization of fish resources in Bangourain Sub Division

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	126.881	3	42.294	85.643	.000[a]
	Residual	41.482	84	.494		
	Total	168.364	87			

a. Predictors: (Constant), Natural, Economic and Cultural Drivers of Innovation
b. Dependent Variable: Spatial diffusion of innovation in the utilization of fish resources

Computed using SPSS version 21

Table 6. Relative coefficients (contributions) of natural, economic and cultural drivers and spatial diffusion of innovations in the utilization of fish resources

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.148	0.194		-0.762	0.448
	Natural drivers of Innovation diffusion	0.214	0.083	0.164	2.574	0.112
	Economic drivers of Innovation diffusion	0.457	0.049	0.538	9.373	0.000
	Cultural drivers of Innovation diffusion	0.428	0.065	0.424	6.579	0.000

a. Dependent Variable: Spatial diffusion of innovation

Computed using SPSS version 21

A single unit change in the standard deviation of natural drivers of innovation triggers a 0.164 change in the spatial diffusion of innovations in the utilization of fish resources in Bangourain though its p-value which is greater than 0.05 indicates that the variance is insignificant. With regards to economic and cultural drivers of innovations, a unit change in the standard deviation of their values would be accompanied by 0.538 and 0.424 shifts respectively in the standard deviation of spatial diffusion of innovations in the utilization of fish resources in Bangourain. This partially confirms that natural, economic and cultural drivers account for high probability of spatial diffusion of innovations in the utilization of fish resources in Bangourain. Whereas the influences of economic and cultural drivers of innovation are significant ($P < 0.05$) as hypothesized, that of natural drivers of innovation is insignificant ($P > 0.05$).

4. CONCLUSION AND RECOMMENDATIONS

Besides increasing overexploitation of fish resources, the status of fish stocks is equally influenced by prevailing climatic conditions – particularly temperatures. This leads to changes in the distribution of species and variability in stock recruitment [1] [20]. Spatial diffusion of innovations in the utilization of fish resources (the dependent variable) was viewed in the light of the level at which fishermen adopts new technology of three finger nets in the utilization of fish resources in Bangourain Sub Division. The indicators used to capture the independent variable of natural drivers of

innovation are the availability of fish resources, while those used for the economic drivers include income received. The study concludes that changes in the natural drivers of innovation triggers a change in the spatial diffusion of innovation in the utilization of fish resources. Furthermore, changes in the economic and cultural drivers of innovation contribute to shifts in in the diffusion of innovations in fish utilization and management. It is therefore plausible to conclude that economic and cultural drivers of innovation are significant as opposed to their natural counterparts. With regards to the findings, this study suggests that the government should provide access to innovation facilities and encourage new innovations such as the use of three finger nets for fishing, the introduction of fish reproduction period and the practice of aquaculture in Bangourain. This will improve the conservation of fish resources and increase fish availability as aquaculture provides the ability for fish production which could be practice by fishermen in Bangourain

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kangur K, Tammiksaar E, Pauly D. Using the "mean temperature of the catch" to assess fish community responses to warming in a temperate lake. Environ Biol Fish; 2021.
   Available:https://doi.org/10.1007/s10641-021-01114-7
2. Grip K, Blomqvist S. Marine nature conservation and conflicts with fisheries. Ambio. 2020;49:1328–1340.
   Available: https://doi.org/10.1007/s13280-019-01279-7
3. Darcy B, Matt M, Karly MM, Serena L, Jono RW, Mary G. Gleason. Opportunities to improve fisheries management through innovative technology and advanced data systems. 2019;20:3.
4. Tracy M, Simon JF, Georgina GG, Steven WP. Adoption and diffusion of technical capacity-building innovations by small-scale artisanal fishers in Fiji. 2019;24:2.
5. Ganesh K, Carole E, Craid T. Factors Driving Aquaculture Technology Adoption. Journal of the World Aquaculture Society. 2018;49:3
6. Jessica B, Reuben S, Daykin H, Rebecca W, Anne-Maree S, David M, Michael P. Social Dynamics Shaping the Diffusion of Sustainable Aquaculture Innovations in the Solomon Islands; 2017.
   Available:file:///C:/Users/EMMULA~1/AppData/Local/Temp/sustainability-09-00126-1.pdf
7. Machena C, Moehl J. Sub-Saharan African aquaculture: regional summary. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand. pp. 341-355. NACA, Bangkok and FAO, Rome; 2001.
8. Elvin S, Constance G. Fish farming as an innovative strategy for promoting food security in drought risk regions of Zimbabwe; 2017.
   Available:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6014019/.
9. Steven JC, Jacob WB, Ben KD, Paul V, William MT, Christian S, et al. Technological innovations in the recreational fishing sector: implications for fisheries management and policy; 2021.
10. Hidemichi F, Yoshitaka S, Atsushi H, John B, Kiyoshi S, Yoshiki M. Research and Development Strategy for Fishery Technology Innovation for Sustainable Fishery Resource Management in North-East Asia; 2017.
    Available:file:///C:/Users/EMMULA~1/AppData/Local/Temp/sustainability-10-00059.pdf
11. Obiero KO, Herwig W, Bryan ON, Jonathan MM, Julius OM, Boaz K. A Predicting uptake of aquaculture technologies among smallholder fish farmers in Kenya; 2019.
    Available:https://link.springer.com/article/10.1007/s10499-019-00423-0
12. Temegne Nono, Carine & Joceline, Momo. Review on Aquaculture Research in Cameroon: Fish Farming. 2019;3. 170.
    DOI:10.23880/ijoac-16000170.
13. Forba CF, Kimengsi JN. Exploring plantation development and land cover changes in the Meme-Mungo Corridor of Cameroon, International Journal of Global Sustainability. 2021;5(1):15-25.
14. Kimengsi JN, Lambi JN, Gwan SA. Reflections on the Role of Plantations in

Development: Lessons from the Cameroon Development Corporation (CDC). Sustainability in Environment. 2016;1(1):1-11.
15. Kimengsi JN, Lambi CM. Pamol Plantations Plc: Prelude to a Looming Population Problem in Ekondo Titi Sub-Division, South West Region of Cameroon. Journal of Sustainable Development in Africa. 2015a;17(3):79-94.
16. Amawa SG, Enjongaya AZ, Kimengsi JN, Sunjo TE. Water Resources Exploitation Practices and Challenges: The Case of River Meme, Cameroon. Journal of Geography, Environment and Earth Science International. 2020;24(6): 13-24.
17. Kimengsi JN, Lambi CM. Reflections on the Natural-Resource Development Paradox in the Bakassi Area (Ndian Division) of Cameroon. Journal of African Studies and Development. 2015b;7(9):239-249.
18. Linjouom Z. Exploitation and Management of Surface Water Resources in Bangourain: Western Region Cameroon. Unpublished DIPES II Thesis, The University of Bamenda; 2018.
19. BUCREP. Third General Population and Housing Census: 3è RGPH, Rapport De Présentation des Résultats Définitif; Résumé; 2005,2010.
20. Pinnegar JK, Engelhard GE, Jones MC, Cheung WWL, Peck MA., et al. Socio-economic Impacts—Fisheries. In: Quante M., Colijn F. (eds) North Sea Region Climate Change Assessment. Regional Climate Studies. Springer, Cham; 2016. Available: https://doi.org/10.1007/978-3-319-39745-0_12

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/72458