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Nexus of Macroeconomic Indicators and Meat Consumption in Saudi Arabia: An ARDL Approach

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Abstract The purpose of this study is to assess the relationship between domestic consumption of meat (red and fish) and its macroeconomics determinants in Kingdom of Saudi Arabia during the period 1980-2020. The Autoregressive Distributed Lag model was used to estimate the short-run and long-run between domestic consumption of meat (red and fish) and Gross Domestic Product (GDP), meat price index, consumer price index and population. The model results revealed a negative significant relationship between domestic consumption of red meat and meat price index, and a positive significant relationship with consumer price index in the long run. The results also depicted a positive significant relationship between domestic consumption of red meat and GDP in the short run. Moreover, the model results depicted a positive significant relationship between domestic consumption of fish and GDP. The study recommended improvement of red meat and fish sub-sectors by supporting producers with loans, storage facilities and supporting the use of modern techniques in fishing to ensure sustainable food supply. This study contributes to literature of food security, and it could support the strategic plan of food security in Saudi Arabia. This is helpful in policy formation to ensure sustainable food supply and fill the gap of the domestic production. It provides valuable information regarding macroeconomic indicators affecting domestic consumption of meat (red meat and fish).

Keywords Autoregressive Distributed Lag Model, Red Meat Consumption, Saudi Arabia

1. Introduction

Livestock sector contributes to agricultural development, poverty reduction and human nutrition, which ultimately result in securing food status. In addition, the sector assists in empowering rural women and young people improving the efficiency of natural resources, and increasing household resilience to climate shocks. The share of livestock sector in total agricultural production in developed and developing countries is estimated at 40% and 20%, respectively. The sector also provides livelihoods for at least 1.3 billion people and 34% of the world's food protein supply [1]. The World Bank recommended that meat production should be increased by about 80% to cover the increasing global demand in 2030. This necessitates efficient use of natural resources in animal production system [2].

FAO [3] stated that food security “exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. Food security has four dimensions: food availability, accessibility, utilization and stability. The availability pillar is measured by the society’s ability to provide sufficient supplies of food to its population through domestic production or international markets. The most significant indicator is the domestic consumption measured by total domestic production plus net imports and stock change [4]. The government of the Kingdom of Saudi Arabia (KSA) develops sustainable and efficient livestock production systems to diversify product and increase the added value of the sector by 2030. This is achieved by developing the agricultural market and improving its efficiency, enhancing food reserves to reduce price volatility, improving the fisheries management, and sustainable management of fisheries and aquariums [5]. Despite the progress of aquaculture in recent years, it is still an emerging sector in terms of production and contribution to economic growth. The per capita consumption of seafood has reached 10 kg year $^{-1}$ and it is projected to reach the global average of 25 kg year $^{-1}$ [6].

The Kingdom is considered as one of the highest red meat consumers in the Middle East and North Africa (MENA), with an investment of about $ 59 billion in food manufacturing sector in 2021. Furthermore, in 2019, nearly $2.7 billion of intermediate inputs for food industry were imported [7]. High Income and population growth are the main drivers for the demand of processed red meat products. In addition, the meat market is expected to expand due to the increase in Hajj and Umrah visitors (from 7 million in 2019 to 30 million in 2030). In 2020, Saudi Arabia has achieved 30% of red meat self-sufficiency, and it planned to increase the ratio to enhance food security as part of the National Industrial Development and Logistics Program in 2030's vision [8].

Animal products (red meat and fish) are major sources of protein. In KSA the production of red meat and fish was estimated at about 165 and 109 thousand tons respectively, the domestic consumption is amounted to about 550 and 291 thousand tons respectively and the self-sufficiency ratio was about 41% and 37% for red meat and fish respectively [9]. Recently, meat food gap has widened due to the population growth reaching about 157.3 and 148.8 thousand tons respectively in 2019, which led the Kingdom to depend on imports to fill that gap. This is reflected negatively on the trade balance, exposing the Kingdom to the international market's shocks. This study aims to analyze the effect of macroeconomics factors on consumption of red meat and fish in the KSA during the period 1980-1920.

Mishaal [10] analyzed determinants of fish demand in Egypt during the period 2000-2014 using the Autoregressive Distributed Lag (ARDL) model. The results showed a negative significant relationship between the domestic consumption of fish and its own price. It also revealed a positive significant relationship between the fish consumption and prices of red meat and poultry and real GDP. The study recommended provision of fish at reasonable prices through fishing encouragement.

The study Erdogdu and Cicek [11] aimed to examine the short-run and long-run relationship between beef consumption and beef prices, chicken meat prices, and per capita income for the period of 1994–2014 in Turkey by employing the ARDL/bounds test approach. Results revealed a positive significant long-term complementary relationship between beef consumption, chicken meat prices and per capita income level, and a negative significant one with beef prices .The study recommended increasing incentives for livestock producers.

Mousavi et al. [12] examined the factors affecting meat imports in Iran during the period (2008-1986) using ARDL. Independent variables were nominal exchange rate, adjusted exchange rate, amount of production, consumer price index and government policies. The results showed a positive significant short-term and long-term relationship between meat imports and government policies.

Al-Sebaei et al. [13] estimated the most important factors affecting the food gap of red meat in the KSA during 2000 and 2018. The dependent variables include domestic production, total consumption, per capita income, red meat imports and population. The study used simple and multiple regressions in the linear and paired logarithmic forms. The results indicated a positive significant relationship between the food gap of red meat and population and the per capita income. The study recommended increasing domestic production through enhancing investments and storage capacity to ensure sustainable red meat supply and maintain price stability.

The study of Ratib et al. [14] aimed to analyze the economic factors affecting fish production and consumption in Egypt during 1996 and 2013 using the multiple linear and step-wise regression analysis in the logarithmic form. Findings showed a positive relationship between the domestic fish consumption and population, and a negative relationship with retail prices of fish and red meat. The study recommended increasing the investments in fishery sector, providing well equipped means of transportation, and establishing fish collection centers near fish sources.

The study of Al-Sebaei and Mansour [15] estimated and forecasted the food gap of meat in the KSA during the period 2000-2014. The study adopted descriptive and econometric method using the linear trend line and exponential smoothing models. The results showed an apparent food gap of red meat, poultry meat, and fish, which reached about 118.6, 489.2, and 104.4 thousand tons respectively. Forecast results showed an apparent food gap increase in 2020, reaching to168.95, 822.0, and 136.3 thousand tons in red meat, poultry meat, and fish respectively. The study recommended focusing on research to improve production efficiency of sheep and goat females and encouraging investments in aquaculture to compensate the shortage in the local supplies.

The purpose of the study conducted by Al-Muhanna [16] was to identify KSA economic policies adopted to achieve food security. It also assessed the economic factors affecting domestic food supplies for some strategic goods between 1990 and 2017. The study employed descriptive and economical method using the co-integration test. The results depicted a positive significant relationship between food security and income, as increasing income will provide a source to cover imports' costs, which is reflected on increasing domestic food consumption. Moreover, it showed a negative significant relationship between food security and international prices and population. The study recommended adoption of appropriate agricultural strategies and implementing effective measures to reduce food loss and waste.

The study of Baskhron et al. [17] examined the most important factors that affect consumption of red and white meat in Egypt and their time trend of production and consumption using multiple regression. The results revealed annual increasing trend of about 1.40% and 2.87% for red meat production and consumption respectively. The results also indicated positive significant relationship between red meat and population and the retail price of white meat. Moreover, it showed a negative significant relationship with real retail prices of red meat and its international prices.

Rehman et al. [18] analyzed the relationship between agricultural GDP as an independent variables and beef, mutton, poultry meat production, and during the period 1982-2018 in Pakistan, adopting an ARDL approach. The results reflected long term relationship between the variables, as there is a positive relationship between agricultural GDP and beef production, and non-significant relationship with mutton and poultry meat production.

Applanaidu et al. [19] employed VAR approach to assess the dynamic relation between food security and some macroeconomic indicators in Malaysia during the period 1980-2012. These variables include biodiesel production, exchange rate, government expenditure on rural development, GDP, food price index and population. The results indicated that, year ten witness the highest shock on food security due to the effect of biodiesel production, exchange rate and government expenditure on rural development variables., while that of exchange rate and population is shown in year five and of GDP in year six.

2. Materials and Methods

2.1. Research Design

The study relied heavily on secondary data covering the period 1980-2020, collected from the Saudi central bank, Food and Agriculture Organization of the United Nations (FAO), Arab Organization for Agricultural Development (AOAD) and the World Bank. The collected data include production, exports and imports of red meat and fish, real GDP, meat price index, population, and consumer price index.

In this study, the Auto Regressive Distributed Lag (ARDL) approach was used to analyze the short-term and long-term relationship between domestic consumption of meat (red meat and fish) and Gross Domestic Products (GDP), consumer price index, meat price index and population in Saudi Arabia during the period 1980-2020.

The ARDL model was estimated as follows:

$$\Delta lnMCR_t = \beta_0 + \sum_{i=1}^{n} \alpha_1 \Delta lnMCR_{t-i} + \sum_{j=1}^{n} \alpha_2 \Delta lnGDP_{t-j} + \sum_{j=1}^{n} \alpha_3 \Delta lnFPI_{t-j} + \sum_{j=1}^{n} \alpha_4 \Delta lnPOP_{t-j} + \lambda ECT_{t-1} + e \quad (1)$$

$$\Delta\, lnMCF_t = \beta_0 + \sum_{i=1}^{n} \alpha_1 \Delta lnMCF_{t-i} + \sum_{j=1}^{n} \alpha_2 \Delta lnGDPN_{t-j} + \sum_{j=1}^{n} \alpha_3 \Delta lnCPI_{t-j} + \sum_{j=1}^{n} \alpha_4 \Delta lnPOP_{t-j} + \lambda ECT_{t-1} + e \quad (2)$$

$$\lambda ECT_{t-1} = lnMCR_{t-i} - \beta_0 - \beta_1 lnGDP_{t-j} - \beta_2 lnFPI_{t-j} - \beta_3 lnPOP_{t-j} \quad (3)$$

Where:

$lnMCR_t$: domestic consumption of red meat, $lnMCF_t$: domestic consumption of fish Domestic consumption = domestic production + imports - export,

β_0 = intercept,

Δ = The first difference

Ln: natural Logarithm

$\beta_1, \beta_2, \beta_3, \beta_4$ = Long run parameters,

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ = Short-run parameters

i, j = Number of Lags,

GDP = Gross Domestic Product,

FMPI = Meat Price Index,

POP = Population,

CPI = Consumer Price Index used as a proxy for fish Price Index.

λ = Speed of adjustment, ECT_{t-1} = error correction term.

2.2. Statistical Analysis

1. Unit Root Test:

The unit root test is used to examine the stationary of the time series for all the variables under study using Augmented Dickey-Fuller (ADF) test, as usage of non-stationary time series may lead to biased or false results. The test null hypothesis states that the time series are non-stationary, and we cannot reject it if the calculated T value is less than the tabulated one, otherwise, the null hypothesis will be rejected, indicating the stationary of the time series [20].

2. Selection of the optimal lag period for ARDL: Akaike Information Criteria (AIC) or Schwartz Bayesian Criterion (SBC) was adopted to determine the optimal lag period of the model.

3. Test of Cointegrating: The Bound Test is used to detect the existence of a long-run equilibrium relationship between the dependent variable and the explanatory variables which tests the following hypothesis:

$$H_0 : \beta_1 = \beta_2 = \beta_n = 0$$

$$H_1 : \beta_1 \neq \beta_2 \neq \beta_n \neq 0$$

The null hypothesis is rejected i.e., there is a co-integration if the calculated F value is greater than the upper limit of the critical values.

If the calculated value (F) is less than the minimum critical values, then we cannot reject the null hypothesis that there is no co-integration between the variables [21].

4. Diagnostic tests were conducted to check model reliability, using the Autocorrelation, Heteroskedasticity and Normality Test. In addition, stability of the model: the model stability was checked using the (Cusum) [22].

3. Results and Discussion

3.1. Unit Root Test

Table 1 clearly shows that the absolute value of calculated T for the variables lnPOP, lnCPI, is greater than the absolute value of the tabulated T at 5% level of significance. Therefore, we can reject the null hypothesis, which indicates the stationary of these variables at level (0). The table also indicates that the absolute value of the calculated T value for the variables lnMCR, lnMCF, lnGDP, and lnFPI are smaller than the absolute tabulated T value at 5% the level of significance. Therefore, we cannot reject the null hypothesis indicating that the variables are non-stationary at level (0). The stationary was examined by taking their first difference, of which the absolute value of the calculated T is greater than the absolute value of the tabulated T, indicating that these variables are stationary at level (1).

Bounds Test

Co-integration test was performed using the Bound test to detect the existence of a long-term relationship between the study variables. The appropriate lag period was chosen according to the Akaike information criterion (AIC). Table 2 explains that the F-statistic value and the calculated t-test value in the red meat and fish model are greater than the upper limit of critical values at 5%t level of significance. This necessitates rejection of the null hypothesis of no cointegration between the model variables, implying the existence of co-integration, that is, existence of a long run equilibrium relationship between model variables.

Table 1. Augmented Dickey Fuller Test Results (ADF)

	Levels (0)		First difference (1)	
Variable	T-Statistic	5%Critical	T-Statistic	5%Critical
lnMCR	0.602	-1.950	-7.973	-1.950
lnMCF	0.830	-1.950	-6.049	-1.950
lnPOP	14.361	-1.950		
lnGDP	1.426	-1.950	-3.053	-1.950
lnFMPI	0.312	-1.950	-5.136	-1.950
lnCPI	2.180	-1.950		

Table 2. Bounds Test Results.

Red meat model	**F-statistic**	F = 11.584					
	t-test	t =- 7.374					
	Significance level	10%		5%		1%	
	critical values	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
	F	2.45	3.52	2.86	4.01	3.74	5.06
	t	-2.57	-3.66	-2.86	-3.99	-3.43	-4.60
Fish model	**F-statistic**	F = 4.750					
	t-test	t = -4.131					
	Significance level	**%10**		**%5**		**%1**	
	critical values	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
	F	2.925	4.037	3.555	4.800	5.034	6.564
	t	-2.582	-3.468	-2.920	-3.850	-3.607	-4.611

3.2. Estimation of Long -run and Short –run Coefficients for Red Meat model

The long-term and short-term relationship of the model was estimated after confirming the existence of co-integration. The appropriate lag period of ARDL model of the red meat is (2,4,4,4,0) defined by the AIC criterion. The model results (Table 3) showed a long-term negative significant relationship between the domestic consumption of red meat and its lagged one-year period. It also revealed a negative significant relationship between domestic consumption of red meat and meat price index, with 1% increase in the meat price index leads to 2.0% decrease in the domestic consumption of red meat. This result is consistent with the economic theory and the result of [17] The model results also depicted a positive significant relationship between the domestic consumption of red meat and the consumer price index, with 1% increase in CPI leads to 2.1% increase in the domestic consumption of red meat. Which illustrates the substitution relationship between red meat and fish. The results also showed a negative significant relationship between domestic consumption of red meat and population; this results confine with [16] of a negative relationship between population and consumption of red meat in KSA. The value of $R^2$was 0.82, indicating that the 82% of change in domestic consumption of red meat is explained by the dependent variable including in the model, while 18% refers to other factors not included in the model. Furthermore, Table 3 revealed a positive significant relationship between domestic consumption of red meat and the GDP in the Short-term, with 1% increase in the GDP lead to 1.5% increase in domestic consumption of red meat. In addition, the results showed a positive significant relationship between domestic consumption of red meat and the meat price index. The error correction coefficient (-1.787768) is negative and significant as expected, meaning that the speed of recovery from short-run disequilibrium to long-run equilibrium convergence is 1.7%.

3.3. Estimation of Long -run and Short –run Coefficients For Fish Model

The appropriate lag periods of fish ARDL is (1,0,0,0) selected by the AIC criterion. The model results (Table 4) showed a negative significant relationship between the domestic consumption of fish, and it is lagged one period time. The results also depicted a positive significant relationship between domestic consumption of fish and GDP, with 1% increase in GDP leads to 0.42% increase in the domestic consumption of fish. This result is consistent with Mishaal (2016), showing that increase in GDP resulted in an increase of domestic consumption of fish. The error correction coefficient (**-**0.57) was significant and negative as expected. It shows that the speed of recovery from short-run disequilibrium to long-run equilibrium convergence is 0.57. The value of $R^2$was 0.79 implying that the independent variables were able to explain 79% of the changes in the dependent variable.

Table 3. Estimation of Long-Run and Short-Run Coefficients for red meat model.

Variable	coefficient	Std. Error	t-statistic	Prob.
long run				
lnMCR (-1)	-1.787768	0.2424421	-7.37	0.000
lnGDP	1575131.0	0.3655792	0.43	0.672
lnPOP	-1.424227	0.495660	-2.87	0.010
lnFMPI	-2.078883	0.372722	-5.58	0.000
lnCPI	2.131676	0.04434199	4.81	0.000
Constant	49.1995	11.82143	4.16	0.001
Short-run				
D (lnMCR (-1))	1.282405	0. 2420588	5.30	0.000
D (lnGDP (-2))	1.515761	0. 5946585	2.55	0.020
D (lnPOP)	7.067347	5.266787	1.34	0.196
D (lnFMPI)	2.851921	0.**7714825**	**3.70**	**0.002**
ETC (-1)	-1.787768	0.2424421	**-7.37**	**0.000**

Table 4. Estimation of Long-Run and Short-Run Coefficients for fish model

Variable	coefficient	Std. Error	t-statistic	prob
lnMCF (-1)	-0.5744577	0.1390693	-4.13	0.000
lnGDP	0.4207712	0.1738734	2.42	0.021
lnPOP	0.7841696	0.471869	1.66	0.105
lnCPI	-1.149019	0.7441142	-1.54	0.132
Constant	-5.169565	3.10833	-1.66	0.105
ETC (-1)	-0.5744577	0.1390693	-4.13	0.000

Table 5. Diagnostic Tests

Test	model	chi2	Prob.
Breusch-Godfrey LM test for autocorrelation	Red meat	3.959	0.0466
	Fish	0.013	0.9079
Heteroscedasticity	Red meat	37.00	0.4226
	Fish	13.08	0.5200
Kurtosis	Red meat	13.86	0.7380
	Fish	0.36	0.5471
Skewness	Red meat	5.76	0.2176
	Fish	1.19	0.2758

3.4. Diagnostic Tests

The Breusch-Godfrey LM test is one of the most key tests to detect autocorrelation. It tests the null hypothesis of no serial correlation against the alternative hypothesis of autocorrelation. Table 5 shows that the calculated chi-squared is greater than 0.05, therefore we cannot reject the null hypothesis, indicating no serial autocorrelation in the model. The Breusch-Pagan-Godfrey test is employed to test the problem of heteroskedasticity, it indicated homoscedasticity of the model as the calculated chi-squared is greater than 5% level of significance. Normality test using Skewness and Kurtosis test revealed that, the data has a normal distribution as the probability of chi-squared is greater than 5% level of significance.

Stability tests were performed after estimating the model and confirming its suitability (free of structural fluctuations over time). Figures 1 and 2 clearly show that the estimated coefficients of the ARDL model concerning red meat and fish are within the critical limits at 5% level of significance in Cusum test.

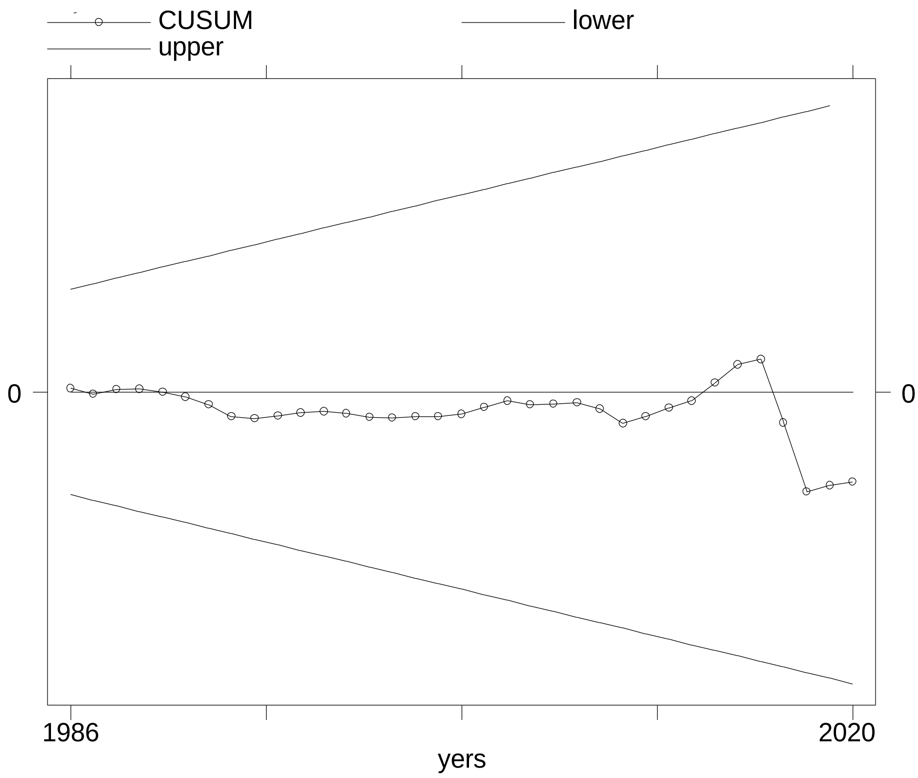

Figure 1. Cusum test results for red meat model

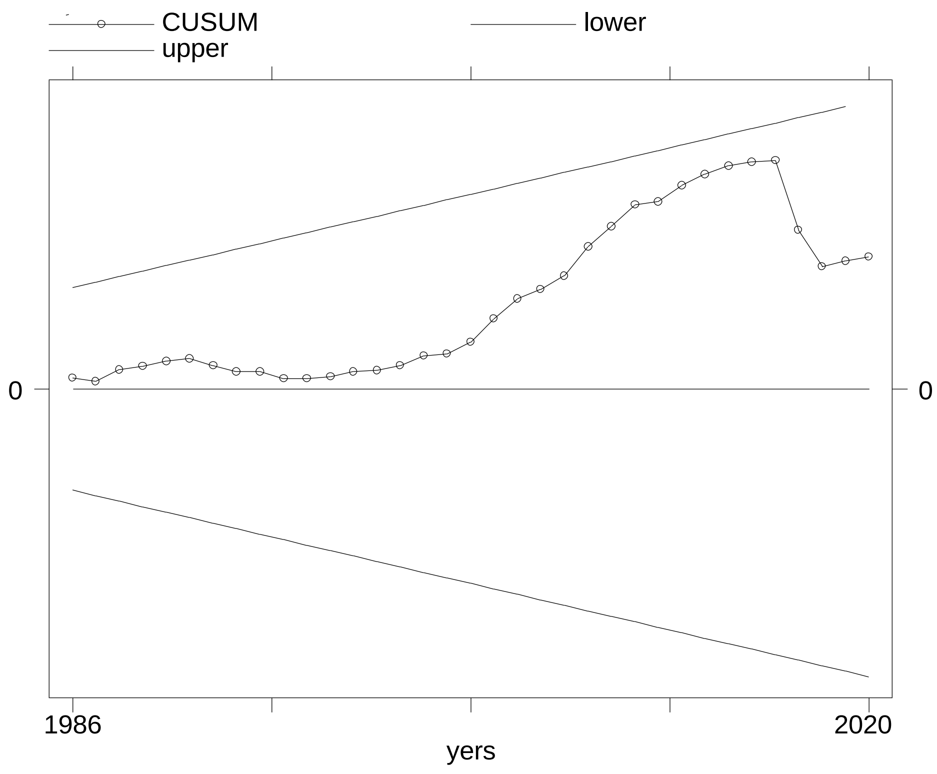

Figure 2. Cusum test results for Fish meat model

4. Conclusions and Recommendation

Livestock sector is one of the crucial sectors to sustain food security in KSA, Recently, the Kingdom depended on food imports due to the increasing demand, which put a burden on the government to cover the import bills. The purpose of this study is to analyze the relationship between domestic meat (red meat and fish) consumption and macroeconomic variables in Saudi Arabia during the period 1980-2020. The model results revealed a negative significant relationship between domestic consumption of red meat and meat price index, and a positive one with CPI in the long run. The results also depicted a positive significant relationship between GDP and domestic consumption of red meat and of fish.

The study recommends improvement of red meat and fish sub-sectors by supporting producers with loans, storage facilities and supporting the use of modern techniques in fishing to ensure sustainable food supply.

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