LAND IRRIGATION AND FOOD PRODUCTION IN DRY-LAND DEVELOPING COUNTRIES

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ABSTRACT

Generally, over 40 percent of the world area is categorized as dry-land developing countries where its accommodate 2.3 billion people mostly in Africa and Asia, and in these regions about one billion people rely on dry-land ecosystem services through rain-fed, irrigated farming and pastoralism. Dry-land areas are categorized by a scarcity of water, which has an impact on food production. Efficiency in irrigation system would help food production sustain especially in dry-land developing countries. Improvement in irrigation could be extended over an additional 110 million ha in dry-land developing countries, producing enough grain for millions of people where more than half of future increases in crop production are expected to come from irrigated land. There are two types of known irrigation systems, namely large-scale and small-scale irrigation. Most of the dry-land developing countries are engaging in small-scale irrigation systems, as they are more affordable than those of large-scale systems, but are still capable of increasing food production. Water harvesting is one of the small-scale techniques of collecting runoff rain water for irrigation purposes and has significantly improved both the yield and reliability of agricultural production. This method has proved successful in Sudan and Kenya. Additionally, the use of low-lift pumps and treadle pumps also provides other linkages of water distribution from domestic use to irrigation. The objective of this paper is to examine the impact of land irrigation to food production in dry-land developing countries. This paper will employ fixed effect analysis and the results shows that land irrigation gives a positive impact to the food production in dry-land developing countries.

Keyword: Food Production, Land Irrigation and dry-land developing countries

1. INTRODUCTION

Dry-land developing countries cover 40 percent of the world's area and accommodate 2.3 billion people. Dry-land areas are most prevalent in Africa and Asia, and in these regions about one billion people rely on dry-land ecosystem services through rain-fed, irrigated farming and pastoralism. Dry-land areas are categorized by a scarcity of water, which has an impact on primary production and nutrient cycling (CGIAR, 2013). Water shortages give an impact crop production, forage, and others plants, and negatively impact human bodies. The Food and Agriculture Organization (FAO) has defined dry land as areas in which the growing period (LGP) lasts from 1-179 days. Besides that, the United Nations Convention to Combat Desertification (UNCCD) has classified these areas as having a ratio of annual precipitation to potential evapotranspiration of between 0.05 and 0.65.

A dry-land area also includes aridity zones in which the average climatic condition is one of limited rainfall and water supplies, also known as drought. According to the United Nations Environment Programme (UNEP), there are three dry-land subtypes known as dry sub-humid, semi-arid, and arid. This type of dry-land is based on the level of aridity or moisture deficit. The level of aridity is based on the ratio of the mean annual precipitation to the mean annual evaporative demand, also known as potential evapotranspiration. Dry-land areas comprise grassland, agriculture lands, forest, and urban areas. These areas provide grain and livestock, forming a habitat that supports many vegetables, fruits, and micro-organisms. Moreover, dry land has high variability in rainfall and experiences prolonged periods of drought. There are four types of drought: First is meteorological drought, which is a measure of the departure of precipitation from normal. Due to climate change differences, a drought in one location is not the same as drought in another. A second type is known as agriculture drought, a condition in which the amount of soil water is no longer sufficient to meet a crop's production needs. Third is hydrological drought, which occurs when the surface and subsurface are below normal. Finally there is socioeconomic drought, where water shortages will affect people (UNDP, 2000).

Table 1.1 shows the aridity zone in dry-land areas. Asia and Africa are the highest aridity areas; Asia's aridity zone, for example, covers 18,401 thousand square kilometers, followed by Africa, where the aridity zone covers 12,933 thousand kilometers square. Based on aridity zones in Dry-Land Developing countries which is based on UNEP (2011) its shows that there is no inequality in food production between these countries because there are no differences in geographical issues.

Table 1: Aridity zones in dry-land areas

Regions	Aridity Zones (1,000km²)			
	Arid	Semi-Arid	Dry Sub-Humid	All Dry Land
Asia	6,164	7,649	4,588	18,401
Africa	5,052	5,073	2,808	12,933
Oceania	3,488	3,532	996	8,016
North America	379	3,436	2,081	5,896
South America	401	2,980	2,223	5,614
Central America and Caribbean	421	696	242	1,359
World Total	15,910	23,739	13,909	53,558

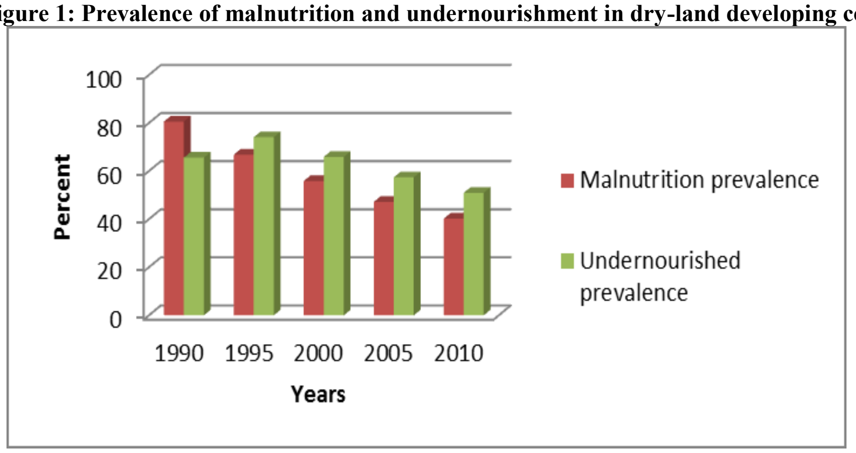
Source: (UNEP, 2011)

Generally food production shortages in dry-land countries are caused by dry-land degradation (UNEP, 2011). The degradation of dry lands is caused by unsustainable land and water use and climate change factors. The World Health Organization (WHO) has found that land degradation is caused by extreme weather conditions such as drought, pollution from human activities, deteriorating quality of soils, and poor land utility, all of which negatively affect food production. Degradation will reduce biological productivity, land irrigation, give an impact on an ecosystem's ability to absorb and use rainwater and direct effects food production.

Insufficiency in food production has been classified as a transitory food security problem. Food production is insufficient due to population increases, especially in dry-land developing countries. Increasing food production is not adequate for all the populations' basic food needs. Insufficient food production will cause an undernourishment problem, increase the food deficit and will cause a food security problem.

Insufficiency of food production and the global food crisis have caused dry-land developing countries faced major problems of malnutrition, hunger, and a lack of proper nutrition. The World Food Programme defines malnutrition as a condition in which those affected have difficulty growing up and are susceptible to disease. Malnutrition also affects people's ability to learn and do physical work. There are two types of malnutrition: first there is protein-energy malnutrition, known as the lack of enough protein and quality food to provide energy to the body. Second, is micronutrient deficiency of vitamins and minerals. The Food and Agriculture Organization (FAO) has defined undernourishment as the proportion of the population whose dietary energy consumption is less than a pre-determined threshold. The threshold is country specific and is measured in terms of the number of kilocalories.

Figure 1: Prevalence of malnutrition and undernourishment in dry-land developing countries.



Source: Food and Agriculture Organization

Figure 1 above illustrates the percentage prevalence of malnutrition and undernourishment in dry-land developing countries. The percentage prevalence of undernourishment and malnutrition decreased from 1995 until 2010. However, in spite of this decrease, the incidence of undernourishment and malnutrition was still high in 2010 (the prevalence of undernourishment was 50 percent and the prevalence of malnutrition was 39 percent). This shows that the food security problem is still a critical issue and needs to be overcome to achieve food security. The prevalence of undernourishment and malnutrition has declined consistently, but this prevalence is still below the global target. Moreover, Food and Agriculture Organization (2014), has identified that 790.7 million people in dry-land developing countries are starving with 226.7 million people is from Africa region, 525.6 million people from Asia Region, 37 million people from Latin America and 1.4 million people from Oceania.

Transitory food security problems, especially food production shortages, have a huge impact on food security in dry-land developing countries. Insufficient food production due to drastic increases in population, and a food crisis resulting from higher food prices have an impact on food shortages and increase the food deficit. This situation causes undernourishment, malnutrition, and hunger.

The Food and Agriculture Organization (FAO) has determined land irrigation area plays an important role in increasing food production and sustained food security throughout the world (Mukherji & Facon, 2009). According to Hasnip & Hussein (1999), 40% of total world food crops are produced through irrigation systems, and another 60% is produced through rain-fed agriculture. However, the highest marginal productivity in crop production is through irrigated agriculture, compared to rain-fed agriculture systems.

Moreover, irrigated agriculture has evolved significantly; world arable land equipped for irrigation has increased drastically, from 21.2 per cent in 2000 to 23.2 percent in 2010. Table 1 below shows that arable land equipped for irrigation in developing countries increased from 28.3 percent in 2000 to 30.4 percent in 2010. The situation is different for least-developed and dry-land developing countries, where the percentage of the irrigation area has reduced drastically due to the high cost of producing a proper irrigation area.

Table 2: Arable Land Equipped for Irrigation

Sub-Groups	Arable Land Equipped for Irrigation		
	2000	**2005**	**2010**
World	21.2	22.4	23.2
Developing countries	28.3	29.7	30.4
Least-developed countries	11.7	11.5	10.7
Dry-land developing countries	16.5	15.5	14.7

Data Source: FAOSTAT

There have been many challenges in the irrigation sector, including a lack of adequate water maintenance and a decrease in technical support (Carruthers et al., 1997). Although certain dry-land developing countries have many river basins and irrigation canals, this has not increased the availability of water for irrigation, especially in the agriculture sector. In addition, more countries are facing severe water shortages because of higher costs of agriculture irrigation systems, which raises the food price index accordingly (Nhundu & Mushunje, 2010). This situation is critical for success in the near future. All North African dry-land countries are already facing acute water shortages and are importing half of their grain (UNEP, 2011). Better and improved water management is the only way to improve food production; otherwise, the prospects of increasing food security are remote.

Irrigation undoubtedly contributes significantly to global food security. The World Bank and United Nations Development Programme (UNDP) estimates show that improved irrigation could be extended over an additional 110 million ha in dry-land developing countries, producing enough grain for 1,500-2,000 million people where more than half of future increases in crop production are expected to come from irrigated land. There are two types of known irrigation systems, namely large-scale and small-scale irrigation. Most of the dry-land developing countries are engaging in small-scale irrigation systems, as they are more affordable than those of large-scale systems, but are still capable of increasing food production. Water harvesting is one of the small-scale techniques of collecting runoff rain water for irrigation purposes and has significantly improved both the yield and reliability of agricultural production. This method has proved successful in Sudan and Kenya. Additionally, the use of low-lift pumps and treadle pumps also provides other linkages of water distribution from domestic use to irrigation.

Thus, sustainable water management for irrigation is a major key to improving food production and reducing undernourishment, hunger, and famine. Some expansion of irrigation areas and improved efficiency of water supply usage will help these countries achieve food security. Failure to achieve efficiency and sustain irrigation areas could have a negative impact on land resources and accelerate the process of environmental degradation. Irrigation and water development strategies have not been given special attention by previous studies because of the lack of understanding of the link among water scarcity, food production, food security, and environmental sustainability (Carruther, et. al., 1997). The objective of this paper is to examine the impact of land irrigation to food production in dry-land developing countries.

2. LITERATURE REVIEW

Generally, domestic food production depends on adequate irrigated land and water. The efficiency of irrigated land will benefit all farmers and increase their food production and hence food supply, reduce hunger, and achieve food security (Dabour, 2002). Moreover, Dowgert et al. (2006) have listed several benefits of irrigation systems in domestic food production, stating that an efficient irrigation system will minimize drought-induced crop failure and famine, which have an indirect positive impact on the environment. In addition, this system will increase nitrogen fertilizer utilization, reduce nitrous oxide emission, increase the value of agricultural land, increase domestic production, and result in crop yield stabilization. Efficient irrigation technology is very important to increase food production, achieve food sufficiency, prevent hunger, and stimulate economic growth (Oriola, 2009). Besides that, climate change has a significant impact on the availability of water and irrigation (Mu & Khan, 2009). These authors have stated that if China were to address the climate change problem in terms of irrigation, it would increase its total grain production from 400 million tons in 2000 to 521 million tons in 2030. Making China's irrigation systems more efficient would directly increase food production and food security in that country.

Food production can improve through land irrigation. Based on a previous study about irrigation and food production in the 21st century, this study has found that irrigation plays an important role in increasing and improving food production (Carruthers et al., 1997). Some changes must be made in terms of expansion of irrigation areas and water supplies, with continuous improvement in the efficiency of existing water supplies usage. However, if improvements in irrigated areas cannot be achieved, land resources will be under increased pressure and the process of environmental degradation will be hastened. Irrigation and water development strategies cannot be achieved due to a lack of knowledge about the relationship among water scarcity, food production, food security, and environmental sustainability.

Moreover, Hassan et al. (2000) carried out a study on the trade-off between economic efficiency and food self-sufficiency using Sudan's irrigated land resources. Sudan has changed its food production strategy to be more dependent on the irrigation sector to improve the food supply, due to food shortages that occurred during the 1980s, which were caused by drought and reduced availability of food. However, this food shortage changed in 1989, when crop yields under irrigated systems increased significantly. This paper has carried out a domestic resource cost analysis to examine whether expansion in irrigation wheat production is more efficient than Sudan's irrigated land resources usage for cotton. The study results show that expenditure on irrigated wheat production in Gezira to ensure food self-sufficiency reduced employment opportunities and impacted economic efficiency. Irrigation systems are important for countries that face drought and erratic rainfall patterns. Ghana is an example of a developing country that has this problem (Burney & Naylor, 2012). The agricultural sector is the main sector in Ghana, employing 86% of Ghanaians.

3. METHODOLOGY AND MODEL SPECIFICATION

3.1 METHODOLOGY

Generally, panel data, which are also known as longitudinal or cross-sectional time series data, is the dataset in terms of the behavior of entities such as countries, regions, companies, and firms observed over time. There are benefits to using panel data estimation because panel data can control all variables that cannot be observed, such as cultural factors; furthermore, this method will control variables that change over time but not across countries or regions. However, panel data estimation has several disadvantages, such as data collection issues in terms of sampling design, non-response in micro panels, or cross-country dependency in terms of correlation between countries in the case of macro panels.

This research will employ a panel data specification test to estimate the first and second objectives by using a fixed-effects model because this model is suitable if unobserved individual characteristics are assumed to be correlated with the error term. Moreover, to check for robustness, this study also applies cross-section analysis for the first objective. Lastly, a dynamic model, known as the Generalized Method of Moments (GMM), will be applied for the third objective of this study.

3.1.1FIXED-EFFECTS AND RANDOM-EFFECTS MODELS

Fixed-effects (FE) models are used to analyze the impact of fluctuating variables over time. Besides that, fixed-effects models are used to determine the relationship between predictor and outcome variables within a country. Each country has its own characteristics that may or may not influence predictor variables. The basic model to estimate this method is shown below

$$y_{it} = \beta_1 x_{it} + a_i + u_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, $a_i \left(i = 1.....n\right)$ is the intercept for each country, y_{it} is a dependent variable, x_{it} is an independent variable, β_1 is a coefficient of the independent variable, u_{it} is an error term, i is a country, and t is a time. The fixed-effects model, using binary variables, is shown below:

$$y_{it} = \beta_0 + \beta_1 x_{1,it} + ... + \beta_k x_{k,it} + \gamma_2 E_2 + ... + \gamma_n E_n + u_{it} \quad \ldots\ldots\ldots.. \quad (2)$$

Where E_n is a country n. By using binary models, which are dummy variables, countries with $\left(n-1\right)$ need to be added to this model, γ_n is the coefficient for the binary regressors. Besides that, this method can also add time effects to the country-effects model to have a time- and country-effects regression model, which is shown as follows:

$$y_{it} = \beta_0 + \beta_1 x_{1,it} + ... + \beta_k x_{k,it} + \gamma_2 E_2 + ... + \gamma_n E_n + \sigma_2 T_2 + ... + \sigma_t T_t + u_{it} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where T_t is a binary variable (dummy), which is $\left(t-1\right)$ time periods, and σ_t is the coefficient for the binary time regressors. Moreover, based on equation (3.77) above, the average of the equation over time for each unit of I will apply as shown below:

$$\bar{y}_{it} = \beta_1 \bar{x}_{it} + \bar{a}_i + \bar{u}_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Next, subtracting the equation as follows:

$$y_{it} - \bar{y}_{it} = \beta_1 \left(x_{it} - \bar{x}_{it} \right) + \left(u_{it} - \bar{u}_{it} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

This equation shows that variables x and y as observations of each panel with their mean per individual have been removed. This equation is also known as the within transformation, and the estimation is known as the within estimator. The within estimator will be unbiased and consistent if all the explanatory variables are strictly exogenous. The within transformation applies the Least Square Dummy Variable (LSDV) model because the regression from LSDV will produce the same result as the model estimated from the original data and a set of $(N-1)$ indicator variables for all but one unit of the panel data. Based on LSDV, the effects of x_1 are based on the differences across countries. When the dummy variable for each country is added, it will show the pure impact from x_1, while controlling unobserved heterogeneity. Additionally, the degrees of freedom for the fixed-effects estimator would be $\left(N(T-1)-k\right)$. A constant term is included and an F-test is required for the null hypothesis test where all the coefficients $a_i^{'}$ are zero, where $a_i^{'}$ are deviations from the mean values $\bar{a}_i$. In a fixed- effects model, time invariance cannot be included because the values will be equal to zero for all time periods. Based on a fixed-effects assumption, all time-invariant characteristics are unique to all countries and cannot be correlated with others countries' characteristics. This fixed-effects model controls all time-invariant differences between countries and will cause the estimated coefficients of the fixed-effects models not to be biased because these models have omitted time-invariant characteristics. If the full set $(T-1)$ of time dummies is added, any explanatory variables that have a constant difference over time for each country cannot be included because it relates to time-constant effects.

An alternative way to substitute a fixed-effects model, is by using a random effects model. The difference between fixed effects and random effects is whether the unobserved individual effect represents the elements that have correlated with the regressors in the model, and it does not matter whether either of these effects are stochastic or not. The random effects model is the most suitable model if the error term or the differences across countries are linked with the dependent variable. Time-invariant variables can be included in this random effects model. The random effects model is:

$$y_{it} = \beta_1 x_{it} + a_i + u_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where u_{it} is a between-countries error and ε_{it} is a within-countries error.

Lastly, to identify whether the fixed-effects model or random-effects model is more suitable for this study, we needed to run a Hausmen test, where the null hypothesis represents the random effects model and the alternative hypothesis is a fixed-effects model.

3.1.2MODEL SPECIFICATION

Food production is one of the food availability components that play an important role in improving food security at national level (USAID, 1992). To feed the populations of dry-land developing countries, food production needs to increase by about 40 percent by 2030, according to an FAO (2006) analysis. Model specifications are based on the theoretical production model adopted from Yuan (2011) and Stern (2006). The model is illustrated below as:

$$\ln FP_t = \alpha_0 + \beta_1 \ln Al_t + \beta_2 \ln LI_t + \beta_3 \ln Am_t + \beta_4 \ln Mr_t + \mu_r + \tau_t + \varepsilon_{it} \quad \ldots\ldots \quad (7)$$

Where FP_t is Food Production in year t, Arable Land Area (Al), Irrigation Area (LI), Agricultural Machinery (Am), Rural Manpower (Mr), regions' unobserved fixed effects (μ_r), time-specific unobserved fixed effects (τ_t), and error term (ε_{it})

This research has changed cultivated area to arable land because Cultivated Area is the sum of total arable land area and total area of permanent crops. This research adopted arable land because the study is focused more on arable land where arable land is land cultivated for crops such as wheat, maize, and rice, while permanent croplands are lands cultivated for crops such as citrus and rubber, so they are not suitable for the estimation. Besides that, this research has not adopted electricity consumption because dry-land developing countries have infrastructural problems, so the data for the electricity are a constraint. This study highlights the impact of land irrigation to food production. The control variables, such as arable land area (Al), determined by the Food and

Agriculture Organization, are a proxy by percent of arable land in agricultural areas. Next control variable is agricultural machinery power (Pm), which, based on the World Bank, is a proxy for agriculture machinery tractors that refer to total wheel, crawler, or track-laying type tractors, and pedestrian tractors used in agriculture. The last control variable is rural manpower (Mr), which, based on the Food and Agriculture Organization (FAO), is a proxy for percent of employment in the agriculture sector. All three control variables are based on Yuan's (2011) approaches. The proxy for food production measurement is based on the food production index, which the World Bank has classified as edible food crops with nutrients. Coffee and tea have no nutrient value. This proxy is then narrowed down to the Net Per Capita Food Production Index Number (2004-2006=100). One of the independent variables is land irrigation, which is important to global food production.

There are many advantages when land is irrigated efficiently. First, irrigation will increase the value of agriculture land, stabilize the agriculture yields, and reduce problems related to drought and famine (Dowgert, 2006). Irrigation also plays an important role in producing high-value crops. Furthermore, based on Carruthers et al. (1997), expansion of irrigation and improvements in water supply management are at the core of improved irrigation efficiency to increase food production. The proxy that will be used to measure land irrigation is the total area equipped for irrigation, which is the area equipped with water through irrigation to all crops, based on the FAOSTAT definition. FAOSTAT states that increasing the irrigation water supply will increase crop production in dry-land developing countries. The expected signs for the estimated coefficients are irrigation area, arable land, agriculture labor, and agriculture machinery will increase food production.

3.1.3DATA DESCRIPTION

The dataset in this research is a panel of observation for dry-land developing countries. This data description is Annual data from 1990 to 2013 is provided for selected 57 dry-land countries. Dry-land countries were selected as a sample because dry-land developing countries have a huge challenge in achieving food security due to hot climates, uncontrollable environmental factors, erosion of arable land, increasing water scarcity, salinization, desertification, disappearing vegetation cover, and loss of biodiversity.

4. EMPIRICAL RESULT

Undernourishment is the main cause of food security problem in developing countries; 790 million people are estimated to be chronically undernourished between 2012 until 2014 in developing countries (FAO, 2014). The goal of decreasing the food security problem can be achieved by increasing food production, and this will help to prevent countries engaging in foreign exchange from purchasing other food commodities from others countries, where the food price fluctuates and is unstable. In addition, the increase in food production will help local populations to access sufficient food. Increased food production is caused by an increase in irrigation and fertilizer usage (Alexandratos & Bruinsma, 2012). However, this situation could be changed in the future due to the dependency on cropland expansion, which occurs as a result of the cost of biodiversity. The assessment of this analysis is based on a static panel data analysis, known as a Fixed Effects Model (FEM) analysis. The data are summarized in Table 3 below.

Table 3: Regression results for the fixed effects model

Food production index	Coefficients
Irrigation Area (AI)	0.1033***
Agricultural Machinery (AM)	0.3284***
Rural Manpower (Mr)	0.0815***
Arable Land Area (AL)	0.0277
Intercept	-0.3897*
Observation	173
Countries	57
R-Square	0.0597
F-Test	51.60***
Breusch&Pagan Lagrangian multiplier	23.90***
Hausman Test	170.17***

*, **, ***significant at 10%, 5%, 1%, respectively

According to the fixed effects analysis above, it shows that irrigation give a positive impact to the food production where based on fixed effects analysis, which shows that the increase of 1 percent in total area equipped for irrigation will increase food production by 0.1033 percent. Irrigation systems help poor and smallholder farmers to increase their yields from crop production. The productivity of crop production is significantly higher in irrigated areas compared to the same crop production under non-irrigated areas (Hussain & Hanjra, 2004). Additionally, this research has adopted three important control variables known as agriculture machinery, arable land and rural manpower. The results of a fixed-effects analysis show that agriculture machinery and rural manpower has a positively significant impact on the food production in dry-land developing countries. However arable land are not significant give an impact to the food production in dry-land developing countries. This empirical result shows that land irrigation gives a positive impact to increase food production in dry-land developing countries.

5. CONCLUSION AND POLICY IMPLICTION

Food is among the basic human needs for social development. Food can be defined as an element people consume to provide nutrients such as carbohydrates, fats, proteins, vitamins, and minerals for the body. It originates from either plant or animal sources. Food absorbed by the body helps to produce energy and stimulate healthy growth. In the past, people traditionally acquired food through primitive hunting and farming methods. Today, our methods of food collection have changed considerably. Most traditional and primitive methods have been sidelined by the introduction of intensive industrial farming and agriculture. Improvements in cultivation methods have also helped to increase production capacity substantially. Food is now a product supplied by industries led by multinational corporations.

These dry-land developing countries have faced food shortages due to high variability in both rainfall amounts and intensity problems. These have faced prolonged periods of drought. A drought is defined as a departure from the average or normal conditions, sufficiently prolonged as to affect the hydrological balance and adversely affect ecosystem functioning and resident populations. In addition, these also faced water scarcity problems, which caused insufficiency in land irrigation. This paper found that land irrigation has a positively significant impact on food production.

Due to the geographical constraint on Dry-Land Developing Countries, the governments, in partnership with public and private institutions, need to work toward defining and implementing comprehensive strategies for irrigation development. There are four important strategies that should be implemented to increase land irrigation areas to boost food production in these countries. The first strategy is to increase the national budgetary allocations for irrigation infrastructure development, and the next is to develop a legal framework to ensure the land rights of farmers, which will motivate farmers to invest in irrigation. Crop diversification will enhance farmers' incomes and viability levels and promote cost recovery from users, which will be adequate to cover the operation and maintenance costs; this is the third strategy. Finally, capacity-building programs should be developed to strengthen, support, and enlighten farmers and encourage farmer participation in irrigation development (Nhundu & Mushunje, 2010).

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APPENDIX

List of Dry-Land Developing Countries

Afghanistan	Guinea	Paraguay
Algeria	Guinea-Bissau	Peru
Argentina	India	Senegal
Angola	Iran	Sierra Leone
Armenia	Iraq	Somalia
Azerbaijan	Jamaica	Sri Lanka
Bangladesh	Jordan	South Africa
Belize	Kazakhstan	Sudan
Benin	Kenya	Tajikistan
Bolivia (Plurinational State of)	Kyrgyzstan	Togo
Bostwana	Liberia	Tunisia
Brazil	Mexico	Turkey
Cameroon	Mongolia	Turkmenistan
Chile	Morocco	Uganda
Cote d'Ivoire	Mozambique	Uzbekistan
Ecuador	Nepal	Venezuela
Egypt	Niger	Yemen
Gabon	Nigeria	Zambia
Ghana	Pakistan	Zimbabwe