The Difference in Paddy Production Through Irrigation and No Irrigation: A Survey of Households in Phalelung Rural Municipality

Kul Prasad Lamichhane[5]

Abstract

This study was designed to examine the difference in paddy production through irrigation and no irrigation, and to explore the problems faced by the farmers in the study area in Phalelung Rural Municipality, as well as their possible solutions. As for the method, this study used the descriptive tools (tables, percentage, means, and standard deviation) and inferential tools (*t* test and interval estimates (95% confidence interval) at the $\propto = .05$ level. Kilograms were used as a unit of measuring the paddy produced by 50 households in both irrigated and no irrigated farmlands. Concerning the first objective, the study found statistically significant evidence in favor of the alternative hypothesis (H_1), at the specified $\propto = .05$ level, that population annual-mean-(paddy) production from the irrigated farmland (μ_1) became larger than that from the nonirrigated farmland (μ_0). Regarding the finding of second objective, on the problems and prospects of farmers, this study found as main problems the lack of irrigation, faulty irrigation management system, lack of technology, monsoon-based agriculture, and low productivity. According to the farmers in the study area, the possible solutions of the problems could be managing irrigation facilities, providing credit, and providing agro-training to farmers.

Keywords: agriculture production, *t* test, irrigated farmland, nonirrigated farmland, problems and prospects

Introduction

Irrigation is crucial for the development of the agriculture sector; however, the sector has not developed properly in Nepal because of its heavy dependence on rainfall. The earliest system irrigation is believed to have begun in 6000 thousand B.C. in Egypt and Mesopotamia. In Egypt, the Nile floodwater diverted to the field for few months each year to enable farmers to grow crop. In Mesopotamia, the Tigris and Euphrates floodwater were used in the same way. Terrace irrigation was an ancient technique used all over the world, including in China and especially in America. Chaco and Hohokama were two kinds of irrigation system in the North America: The

[5] Lamichhane is Associate Professor Department of Economics, Ratna Rajyalaxmi Campus, TU. Email: lamichhanekul@gmail.com

Chaco irrigation was used in Mexico, and the Hohokama one in Arizona. The Dujiangjy an irrigation system of China, built in 256 B.C., irrigated huge agriculture land (Andreas et al., 2020).

Farmland is irrigated in Nepal mainly through small and medium type of irrigation system. The irrigation system from underground system is a main source of livelihood for most Nepalese. A majority of people in Nepal seem to depend on rain-fed water for irrigation. In 1923, Nepal government-built infrastructure of the modern engineering technique of Chandra canal, a large-scale irrigation structure; similarly, another large scales irrigation structure, Juddha canal, was built in 1940 in Nepal. In 1952, the department of irrigation was set up to develop Nepalese's irrigation system. A farmer management irrigation system was set up by the then government to manage irrigation. A new and system of developing irrigation seems to have started from the first five years plan; large-scale irrigation structures were then constructed in different parts of the Terai with the World Bank's assistance. About 100 years ago, Rani, Jamara, and Kuleriya irrigation systems were constructed by farmers themselves to irrigate 15000 hectares of land. The study focused on the need for increasing agriculture productivity to become self-sufficient in food and to minimize poverty (Pradhan and Belbase, 2018).

Objectives

This study was designed to examine the difference in paddy production through irrigation and no irrigation, and to explore the problems faced by the farmers in the study area in Phalelung Rural Municipality, as well as their possible solutions.

Hypotheses

For this objective, this study has set these two hypotheses for the population-mean paddy production (μ_i) consisting of two hundred household farmers (N = 200), using one (right) tailed test based on the experiences and practices: The null hypothesis is that there is no difference in the population-mean paddy production through irrigation and no irrigation (that is, H_0: $\mu_1 = \mu_0$) against the alternative hypothesis that the population-mean paddy production through irrigation is greater than that through no irrigation (that is, H_1 : $\mu_1 > \mu_0$) , where i = 1, 0; the subscript 1 ≡ irrigation; the subscript 0 ≡ no irrigation; H_0 ≡ null hypothesis; H_1 ≡ alternative hypothesis.

Review of Literature

The agriculture sector, having about 64.4% of total population, contributes 27% to GDP. The fifteenth plan aims to increase the contribution of the agriculture sector to 23% by the end of the planning last year. This plan aims to maintain traditional irrigation and to construct new technical irrigation structures—as well as to achieve the trade balance in agriculture sector by becoming self-reliant in major agriculture products by the end of this plan (National planning commission [NPC], 2019/20–2023/24).

The significance of farmer-managed irrigation systems in Nepal is viewed in different ways. At the household level, many families in hills rely on the increased production, for their survival, made possible by their irrigation systems. At the national level, on the other hand, at least 45 percent of the population's subsistence cereal requirement is being fulfilled by the growth in food production made possible by irrigation from farmer-managed systems (Ghimire, 2017).

United States Geological Survey (USGS, 2017) reported the controlled application of water for agriculture purposes through man-made system to supply water requirements satisfied by rainfall. USGS found crop irrigation to be vital for feeding the world's ever-growing population. It pointed out different irrigation systems used worldwide: center pivot, micro-irrigation, flood or furrow, spray or sprinkler, sub-irrigation, and surge flooding.

Nepalese farmers, recognizing the importance of water resources for years, have been building irrigation systems at their own initiatives to increase their agriculture production. This tradition has given birth to the farmer-managed systems across Nepal. These systems have been developed by their own rules, norms, and procedures of the management. In 2002, the irrigation potential of the country was estimated at 2,177,800 hectares, including some 412,000 hectares not cultivated mainly in the Terai area—the potential mainly for surface irrigation. Some 352,050 hectares, however, were potentially irrigable from groundwater in the Terai region (Thakur, 2015).

Paudyal (2010) investigated the relationship between canal irrigation and the growth in agriculture production and found canal-irrigated farmland to give more paddy production than the tube-well irrigated farmland: Thanks to canal irrigation, paddy production increased by 68.75 percent and wheat production by 193.0 percent.

Malla (2008) investigated the impact of the climate change on agriculture and environment, using secondary data. Malla described a rapid rise in temperature and evaporation—due to climate change—as a reason for an increase in rainfall and an increase in water resources in main catchment rivers, including Koshi, Gandki, Karnali, and Mahakali, thereby increasing agriculture production because of the availability of irrigation facilities. The author, however, found no clear link between short- and long-run increases in agriculture production and recommended developing irrigation infrastructure and minimizing the use of agro chemicals to save the long-run increase in agriculture productivity.

Uprety (2005) argued that organizations were designed for the acquisition of water, mobilization of manpower and local resources to the operation and maintenance of the system, equitable water distribution, and minimizing conflict. The nature of water as a transient resource requires co-operative sharing of irrigators to utilize and manage it for irrigation.

Uphoff (1986) advised to address these basic issues: a physical structure of allocating, distributing, and collecting of water; and an interactive and mutually dependent organization, usually managed by a social organization.

Ricardo (1817) divided lands into four grades according to their agriculture productivities: different grades of lands cultivated gradually in a descending order with superior grade of land cultivated at first, then second grade of land, third grade of land thereafter, and finally fourth grade of land with population growth and the resultant increase in the demand for agriculture products.

Looking at the previous review of literature done so far, no studies were found on Phalelung Rural Municipality Panchthar and on this topic; for this reason, this study seems to have filled geographical and variable gaps.

Method

Based on the above objectives, the study methodology has ranged from the demographic characteristics to data processing tools and style of writing.

Study Area and Demographic Characteristics

Two canals have remained in operation in the study area: Tindobhane and Khursane. The study area, in Phalelung rural municipality (Ward No. 2) bordered by Sikkim and West Bengal of India, Panchthar, has included these demographic characteristics—(a) Religion: Hindu, Kirat, Buddhism, and Christian; (b) caste and ethnicity: Limbu, Rai, Chhetri, Brahmin, Tamang, Bhujel, Kami, and Damai;(C) education background: most members illiterate and some literate; (d) language: Nepali, Limbu, Rai, and Tamang; (f) economic status: lower-middle classes of the people; and(g) occupation: main agriculture.

Time Horizon

The cross-sectional data were collected during three months from April 2020 to June 2020.

Research Design

To analyze the data, this study employed a descriptive, inferential, quantitative, and household level design, as well as after-only design with control area (the farm area with no irrigation facility).

Sources of Data

Using field survey, this study collected primary data from the farmland with no irrigation facility (control area) and the farm area with irrigation facility (treatment area).

Population and Sample Size

The sample sizes in this study comprisedn_1 = 50 units (households) for the farmland with irrigation facility and n_0 = 50 units (households) for the farmland with no irrigation facility. The population size consisted of200 households (N = 200).

Sampling Design

The sample data ($n_1 = n_0 = 50$) were collected by using simple random sampling because of the homogenous nature of households in the population.

Methods of Data Collection

This study collected the data by using semistructure questionnaires and personal interview (face-to-face, pen-and-paper interviews).

Tools of Data Analysis

Both descriptive and inferential tools of statistics were used to analyze the data. The descriptive tools included tables, percentage, means, and standard deviation. Inferential tools included an interval estimate for the population mean (95% confidence interval) and *t* test. Kilograms (a ratio or metric scale) were used to measure the paddy produced by 50 households in 2 *ropany* land related to both irrigated and no irrigated area.

This study used the *t*-test for two independent samples because of heteroscedastic variances in the samples [$(\hat{\sigma}_1^2 \neq \hat{\sigma}_0^2) \Rightarrow (\sigma_1^2 \neq \sigma_0^2)$] and because of this study's data meeting these four conditions for the use of this *t* test (see also Cleff, 2019, p.286, for these four conditions): (i) ratio or interval (cardinal or metric) scale of measurement (In this study, the production was measured in metric scale like kilograms.); (ii) random sampling (Because of the homogenous nature of data and respondent households, simple random sampling was used to select the sample of each of the 50 respondents from the population size of 200 households.); (iii) independent samples (This study used two nonoverlapping samples of the paddy production from the irrigated and nonirrigated farmlands.); and (iv) the test variables to be normally distributed or a larger sample size ($n \geq 30$) (This study used the sample size of 50 farmer respondents.).

$$t = \frac{\bar{x} - \bar{x}_0}{\hat{\sigma}\bar{x}_1 - \bar{x}_0} = \frac{\bar{x}_1 - \bar{x}_0}{\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_0}}},$$ whereH$_0$: $\mu_1 = \mu_0$againstH_1: $\mu_1 > \mu_0$(right tail).

Degree of freedom (*df*) $= \frac{[\left(\frac{\hat{\sigma}_1^2}{n_1}\right)+\left(\frac{\hat{\sigma}_2^2}{n_0}\right)]^2}{\frac{(\frac{\hat{\sigma}_1^2}{n_1})^2}{n_1-1}+\frac{(\frac{\hat{\sigma}_2^2}{n_0})^2}{n_0-1}}$. Moreover, the decision rule: At $\alpha = .05$ (one tail) and at the above defined *df*, support H_1: $\mu_1 > \mu_0$ if $|t_{computed}| > t_{tabulated}$.

The 95% C.I. for μ_i=[$\bar{x} \pm 1.96 \frac{\hat{\sigma}_X}{\sqrt{n}} . \sqrt{\frac{N-n}{N-1}}$], where $\hat{\sigma}^2{}_{X_i} = \frac{\sum x_i^2 - \frac{(\sum x_i)^2}{n_i}}{n_i - 1}$ and

$\hat{\sigma}_1^2 \equiv$ sample variance of the paddy from the farmland with irrigation facility; $\hat{\sigma}_0^2 \equiv$ sample variance of the paddy from the farmland with no irrigation facility; $\overline{X_1} \equiv$ sample mean of paddy in farmland with irrigation facility; $\overline{X_0} \equiv$ sample mean of paddy in the farmland with no irrigation facility; $\mu_{1} \equiv$population-mean paddy production in the farmland (related to 200 households) with irrigation facility; $\mu_{0} \equiv$population-mean paddy production in the farmland(related to 200 households) with no irrigation facility; N =200 household farmers = population size; n_1= 50 = sample size (irrigated paddyland); and n_0= 50 = sample size (nonirrigated farmland).

Data Processing Tools and Style of Writing

This study used Excel 10 for processing the primary data and used *American Psychological* (APA, 6th.ed.) for parenthetical citation, narrative citation, and references.

Results

Based on the above objective and methods, this study has analyzed the data here.

Comparing Aggregate Paddy Production from Irrigated and Nonirrigated Farmlands

Table 1 shows paddy production in irrigated and non-irrigated farmland in this study area.

Table 1

Comparison of Aggregate Paddy Production

Farm land (X)				Grand	
Irrigated (X_1)		Nonirrigated (X_0)			
Total production (ΣX_1)	Percent (%)	Total production (ΣX_0)	Percent (%)	Total production	Percent (%)
12,546	60	8,315	40	20,816	100

Note. The production measured in kg per year. Computed from the data from the field survey, 2020.

According to Table 1, the total production of the paddy in this study area was 20,816 kg. Out of the total production (20,816 kg), the production from the irrigated farmland accounted for

60% (12,546) and that from the nonirrigated farmland 40% (8,315kg). The paddy production from the irrigated farmland was found to be more than that from the nonirrigated farmland by 20% (4,263 kg).

Comparing Population Means of Paddy Production from Irrigated and Nonirrigated Farmlands

Table 2 compares annual mean paddy production from irrigated and nonirrigated farmland.

Table 2

Annual Means-Paddy-Production from Irrigated and Nonirrigated farmland ($\bar{X}$) and ($\bar{X}_0$)

Dependent variable	Irrigated farmland	Nonirrigated farmland
	$\bar{X}_1$	$\bar{X}_0$
Annual paddy production	250.92	166.3

Note. Figure in annual–mean paddy production here measured in kg per year. N_1= N_2= population of irrigated and nonirrigated farmland =100*;* n_1 =n_2 =50. Computed from the data from the field survey, 2020.

As shown Table 2, the annual mean-paddy production of the irrigated farmland (250.92 kg) became greater than the annual mean-paddy-production of the nonirrigated farmland (166.3 kg) in the study area. To test whether the arithmetic-mean difference is statistically significant, this study used *t*-test of two independent samples to test the null and alternative hypotheses that $H_0: \mu_1 = \mu_0$ and $H_1: \mu_1 > \mu_0$, as shown in Table 3.

Table 3

The t-Test Results of the Annual Mean-Paddy Production from Irrigated and Nonirrigated Farmlands ($\bar{X}$) and ($\bar{X}_0$)

Computed *t* value	Critical *t* value	*df*	Significant level (α): right tail test	Decisions
8.27	1.67	81.63	.05	Because computed *t* value > critical *t* value, alternative hypothesis (H_1:$\mu_1 > \mu_0$) was retained, meaning that the population-mean production of paddy from the irrigated farm land (μ_1) became greater than that from the nonirrigated farmland (μ_0).

Note. Here population size ($N_1 = N_0 = 100$); sample size($n_1 = n_2 = 50$). $H_1: \mu_1 > \mu_0$.

Computed from the data from the field survey, 2020.

According to Table 3, the calculated t(= 8.27) became greater than that of tabulated value of t (81.63) =1.67at the specified .05 level; hence, the alternative hypothesis *(H1*) was supported—showing a statistically significant difference in the population-mean paddy production, as anticipated in the hypothesis, and providing a statistical evidence for the population–annual-mean paddy production from irrigated farmland (μ_1)being greater than that from the nonirrigated farmland (μ_0).

Point and Interval Estimate for Population-Mean Paddy Production from Irrigated and Nonirrigated Farmlands

In Table 4, this study reported point and interval estimates for population-annual–mean paddy production (μ) from the irrigated and nonirrigated farmlands.

Table 4

Point and Interval Estimates for Population-Annual-Mean-Paddy Production of Irrigated and Nonirrigated Farmland

	Irrigated farmland		Nonirrigated farmland	
	Point estimate $\bar{X}_1(\hat{\sigma}_1)$	Interval estimate 95% CI	Point estimate $\bar{X}_0(\hat{\sigma}_0)$	Interval estimate 95% CI
Annual production (in kg)	250.52 (61.52)	[235.68 , 265.36]	166.16 (37.99)	[157.14 , 175.46]

Note. The figure on annual-mean-paddy-production of irrigated and nonirrigated farmland here measured in kg per year. N_1 = population size of irrigated farmland = 200; μ_i = population-mean-paddy production of irrigated and nonirrigated farmlands; $n_1 = n_0$=sample size of both lands;$\bar{X}$ = sample mean,$\hat{\sigma}$ = sample standard deviation; 1= irrigated farmland; 0 =nonirrigated farmland; CI = confidence interval. Computed from the data from the field survey, 2020.

From Table 4, it appears that the population–mean-annul paddy production of irrigated farmland was estimated to be around 251 kg (as a point estimate of population mean), but its interval estimates were projected to be at the range from around 236 to 265 kg. Likewise, the population–mean-annual paddy production of nonirrigated farmland was estimated to be around 166 kg (as point estimate of population mean), but its interval estimates were projected to be at the range from 157to 175 kg. This finding suggests therefore that the irrigated population-mean-annual paddy production (in kg) became greater than nonirrigated population-mean-annual paddy production (in kg).

Problems and Possible Solutions

Based on semistructured questionnaires and face-to-face personal interviews with respondent farmers in this study area, the following problems and possible solutions were found in this study.

Problems Faced by Farmers in the Study Area

The following problems faced by farmers were found in the study area: the lack of the timely use of chemical fertilizers and improved verities of seeds; natural disasters (such as landslides)that cause damage to canal; different types of wildlife (such as monkey, deer, and porcupine) that damage crops; no modern technology and training to farmers to increase agricultural productivity; farmers far from the source of the canal facing the problem of irrigation due to inadequate irrigation management system; farmland with no irrigation facility to depend on monsoon rain alone; farmers frequently harassed by drought ;lack of concessional agriculture credit to the farmers in the study area; the problems of insects destroying crops in the farmlands in the study area; and no proper and timely facilities of pesticides.

Possible Solutions Offered by the Respondents to the above Problems

The government should increase investment in irrigation. Water User Association should equitably manage the water distribution system. The concerned stakeholders should arrange for improved seeds and agro-training to increase the productivity of agriculture. An arrangement should be made for easy access to modern agriculture equipment concessional loan. Finally, the stakeholders should take some steps in preventing wild animals from damaging crops.

Discussion and Conclusion

Discussion

In accordance with the above two objectives and method, this study has made these findings. Because the alternative hypothesis (H_1) was supported, this study found statistically significant difference in population-mean annual paddy production, in the study area, from the irrigated and nonirrigated farmlands at the .05 level, computed t (81.63) = 8.27, critical t =1.67—indicating that population annual-mean-paddy production from the irrigated farmland (μ_1) became larger than that from the nonirrigated farmland (μ_0), as anticipated in the alternative hypothesis.

Regarding the second objective on the farmers' problems and the possible solutions, this study found as main problems the lack of irrigation, faulty irrigation management system, lack of technology, monsoon-based agriculture, and low productivity. According the farmers in the study area, the possible solutions of the problems could be managing irrigation facilities, providing credit, and providing agro-training to farmers.

Because of a small sample size (n_1=n_0 = 50) and its target population (*N* = 200), however, these findings (a static picture related to cross-sectional data) may not be generalizable to others study areas. Hence, the use of longitudinal data and more advanced econometric tools would enable future researchers to reach closer to a dynamic picture on the difference in the paddy production from the farmlands with irrigation and with no irrigation.

Conclusion

As for the first objective, the study found computed paired *t* values having greater than their critical *t* values; this finding has lent support to alternative hypothesis(H_1). The support of H_1hasbrought this researcher to the conclusion that paddy production from the irrigated farmland seemed to be more than that from nonirrigated farmland. Here, the irrigation may have played an important role in making the production from the irrigated farmland larger than the production from the nonirrigated farmland.

If the main problems (the second objective)—the lack of irrigation, faulty irrigation management system, lack of technology, monsoon-based agriculture, and low productivity—are addressed by the concerned authorities, then their solutions (as well as the other possible solutions as put forth by the farmers in the study area, such as managing irrigation, providing credit, and providing agro-training to farmers) are very likely to further increase the paddy production in the study area.

This study, as well as its findings, could hold some practical and social significances—a practical significance because the problems and possible solutions put forth by farmers may be useful for policy makers and a social significance because this study's findings could be useful for future researchers to build on the study in this topic.

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