Impact of Irrigation Management Practices on Land and Its Productivity in Addressing Hunger and Poverty

Birendra KC¹, Bart Schultz², and Krishna Prasad³

ABSTRACT

Improvement in land and water productivity of existing irrigation and drainage schemes will be required to meet the increasing food demand and attenuate poverty. However, current practices of irrigation water management in quite some schemes are at a low level, with outputs per unit of arable land and irrigation supply substantially below potential. With the view to enhance the productivity levels, this paper analyses various agriculture development and irrigation water management practices in existing irrigation schemes. Based on geographic, economic and climatic conditions four sample schemes were selected for the study comprising two schemes from least developed and two from emerging countries. These schemes represent different water management policies and irrigation supply technologies. The studied schemes include: Sunsari Morang Irrigation Scheme (Nepal) and Goha W Irrigation Scheme (Ethiopia) from the least developed countries, and Sri Ram Sagar Irrigation Scheme (India) and Yaqui Irrigation District (Mexico) from emerging countries. Organizational, financial, technological and operational indicators were used to evaluate the land and water productivity in these schemes. CropWat 4 was used to estimate the potential yields of the currently cultivated crops. The results of the analysis show that institutional and technological improvements can contribute significantly to land and water productivity increment.

JEL Classification: O22, O40, I31

Keywords: Land and Water Productivity, Irrigation and Drainage Schemes, Poverty, Agricultural Development, Irrigation Water Management, CropWat 4, Potential Yields

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1. Introduction

The emerging and least developed countries are now profoundly confronted with the need to increase agricultural production to meet the substantially increasing food demands, for which significant improvements of existing irrigation and drainage schemes are a prerequisite (Schultz, 2003; Schultz et al., 2005, 2009). Growing competition on finite and limited water resources and increasing realization of its socio-economic importance to the society and environment calls for improved water productivity (Molden & Rijsberman, 2001). This implies that growing more food with less water will suffice to make more water available for other natural and human uses (KC, 2016; KC, et al., 2016). Keeping this in mind, human civilizations for long has been trying to make efficient use of available water in several ways to improve the living conditions (Schultz, 2003). Yet, many irrigation and drainage schemes, particularly in the emerging and least developed countries, are performing below their potential (Raju & Kumar, 1999).

Currently, around 42% and 62% of the total population, respectively, in the emerging and least developed countries depend on subsistence agriculture. However, large number of people are facing seasonal or year round food scarcity. Comparatively, the situation is worst in the least developed countries where almost 50% of the populations live on less than US$ 1 a day (United Nations Office of the High Representative for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS), 2008). In the emerging countries, though the food deficit per person is minimal, the impact of urbanization and development of bio-fuel cultivation is significant (Tardieu and Schultz, 2008).

To meet the increased demand, food production will have to be doubled by next 25 to 30 years, for which the effective management of land and water resource of the irrigated area in emerging and least developed countries is a crucial point (Molden, 2007; Tardieu and Schultz, 2008; Schultz et al., 2009; Food and Agriculture Organisation (FAO) & International Commission on Irrigation and Drainage (ICID), 2014). Land and water management for better food production can be attained from three different ways: improving productivity of the rainfed area, establishing new irrigation and drainage schemes (where there are no irrigation water management facilities), and improving the productivity of existing schemes (Ararso et al., 2009; Schultz, 2012). Since the higher yields that can be obtained from irrigated areas may be more than double the highest yield that can be obtained from rainfed areas, irrigated agriculture has been realized as an extremely important source of food production. Similarly, as the investment for productivity improvement per unit irrigated land is cheaper than irrigated area expansion, productivity improvement of the existing irrigation and drainage scheme has drawn higher attention over all kinds of agriculture.

Some of the main shortcomings in the prevailing irrigation management practices are: improper design, mismanagement, lack of financial and technical capacities, and lack of a reasonable price for the products (Ararso et al., 2009). However, the shortcoming relating to reasonable price for the products has changed since 2007 most probably resulting in a new push to the development of irrigated agriculture (Figure 1). Therefore, the challenge will be to cope with the required increase in food production (Steduto et al., forthcoming).

In practice, many options and technologies are in use to make effective use of land and water resources for irrigated agriculture. These include from simple traditional water harvesting systems to sophisticated sprinkler and drip irrigation systems. Similarly, to

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4 Detail information on how the emerging and least developed countries are classified is available in KC et al. (2011) & KC (2008).
implement agriculture development policies various institutional arrangements are in place including from traditional social-oriented to the modern business-oriented water users associations (WUA) (KC, 2008). In the same context, a variety of provisions for cost sharing, operation and maintenance, and irrigation fee collection and distribution are being applied in practice (KC et al., 2009). The suitability of these technologies and institutions highly depends on the local climatic conditions and farmers’ understanding and interest.

Figure 1: Development of prices on the world market for some basic food crops (Source: Steduto et al., forthcoming).

This study assesses various irrigation supply technologies and institutional arrangements adopted in four example schemes covering both least developed and emerging economies to achieve the objective of production improvement. Using FAO CropWat modelling, yield reductions of the prevalent crops at the existing climatic conditions and irrigation supply in the four example schemes are assessed. This gave an idea about how far the present productivity levels are from the achievable limit. The results of the analysis indicate that the institutional and technological arrangements play a key role in land and water productivity increment. The following section discusses the methodology, Section 3 outlines the results and their interpretations, socio-economic impacts of the study are presented in Section 4, and Section 5 concludes.

2. Methodology

A comparative study was conducted taking four sample schemes comprising two from least developed and two from emerging countries. The four example schemes comprising one from each of Nepal, India, Ethiopia and Mexico were taken to represent different geological and economic conditions. Also, the four irrigation schemes were selected by considering various irrigation water supply technologies and institutional arrangements. The selected schemes were: Sunsari Morang Irrigation Scheme (SMIS) in Nepal and Goha W irrigation scheme (Goha) in Ethiopia to represent least developed countries, and Sri Ram Sagar Irrigation Scheme (SRSIS) in India and Yaqui Irrigation District (Yaqui) in Mexico to represent emerging countries.

This research was mostly based on secondary data. Various literatures along with existing databases of FAO, IWMI and ICID were used to collect the information for the land and water productivity evaluation. In cases of multiple data sources, the most reasonable ones were adopted after comparative scrutiny. Climatic data were obtained from CLIMWAT-database of FAO. Various default settings of FAO CropWat programme were checked with
Irrigation and Drainage Paper No. 24 (crop water requirements), No. 33 (yield response to water) and No. 56 (crop evapotranspiration).

FAO CropWat 4 version Windows 4.3\(^5\) was used to estimate yield loss of various crops under existing crop cultivation and irrigation management practices. Potential yields were taken from Irrigation and Drainage Paper No. 33. Then actual yields were computed by deducing yield loss from potential yield. As FAO CropWat 4 Windows 4.3 does not work for Paddy, prevailing productivity of paddy was directly taken from the Ministry of Agriculture and Co-operatives (MOAC) (2003) and FAO (2000), respectively, for SMIS and SRSIS.

Water productivity assessments were made based on relevant indicators identified in various literatures. Most indicators were adopted from Molden et al. (1998). In addition, organizational, financial, technological and operational indicators were used to identify the performance and main shortcomings in the prevailing management of the four schemes as follows:

- **Organizational indicators**: farmer’s involvement in WUA formation, management type of the scheme, legal status and autonomy of the WUA and transparency;
- **Financial indicators**: farmer’s income, willingness to pay irrigation service fees, cost recovery, revenue collection and operation and maintenance cost per unit of irrigation supply;
- **Operational indicators**: water right, provision of tradable water use right, basis of water pricing; and sharing of responsibility for operation and maintenance (O&M).

Land and water productivity were used as indicators for agricultural outputs to identify the gaps between potential and prevailing yields.

3. Results and Discussion

3.1. Brief Introduction of the Selected Irrigation Schemes

SMIS is the outcome of Koshi Agreement reached between the Governments of Nepal (GON) and Government of India (GOI) in 1954. The objective of the project was to irrigate 64,000 ha land lying at south eastern Terai in Sunsari and Morang districts of Nepal. SRSIS was constructed by the Government of India in 1963 with an objective of irrigating 392,162 ha land in Nizamabad, Adilabad, Karimnagar and Warangal districts of Andhra Pradesh state of India. Goha W irrigation scheme lies in Goha Worko village in central part of Oromia region of Ethiopia with irrigable area of 150 ha. The water source of the scheme is Wedecha dam constructed by Cuban Civil Mission in collaboration with the Water Resource Development Authority (WRDA) of Ethiopia in 1980.Yaqui irrigation district lies in North West of Mexico in Sonora State. The district is served by irrigation infrastructure of the 20\(^{th}\) century covering between 6,000 ha and 10,000 ha of irrigated land.

SMIS and SRSIS are jointly-managed irrigation schemes with canal networks below secondary level, managed by the concerned WUAs and secondary level and above this by government agencies, while Goha W and Yaqui Irrigation District are farmer-managed irrigation schemes where WUAs are fully responsible for the operation and maintenance of the whole scheme. The detailed information about the selected irrigation schemes is available in KC (2008).

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\(^5\) A tool developed by the Land and Water Development Division of FAO to calculate evapotranspiration, crop water and crop irrigation requirement.
3.2. Water Use Right

In all four schemes, there exist some provisions of defining water use rights of the users for irrigation. In principle, all users are entitled to receive the demanded water. Comparatively, the situation is worst in SMIS. Although at country level in Nepal the Irrigation Regulation 2000 has defined water use right, at scheme level there exist no specific rules and regulation for supplying water in an equitable manner (Timilsina, 2006). In the other three schemes, the water use rights have been clearly defined. For example, in Goha, the goal is to provide each user with a fixed amount of water per unit area (Hundie, 2006). In SRSIS, the water use right mechanism provides the right to irrigation water for all landowners, tenants and other users in the command area.

However, the actual implementation of water use right in SMIS, SRSIS and Goha was more or less the same. Tail end farmers were always raising the voice of dissatisfaction. It was found that in SRSIS farmers were not well aware about their water use rights due to the prevalent illiteracy among them and their representatives. Therefore, the state government tried to publicize the right through various awareness activities like political statements, trainings, posters and public campaignings. The situation was far better in Yaqui where as far as possible farmers received all irrigation supplies based on predefined allocation. The supply covered almost full crop irrigation demand. It was possible due to clearly defined water use rights, their effective implementation and the water storage reservoir of the scheme. In addition, farmers were allowed to buy water use rights from the nearby users in the command area enabling them to manage required volume of water to meet the crop water demand. In other words, buying/selling water use right improved the reliability in irrigation supply and accelerated the productivity.

3.2. Irrigation Supply Technology and Water Allocation

Full control surface irrigation\(^6\) is the common irrigation supply technology adopted in the four irrigation schemes. In SMIS about 84% and in SRSIS about 70% of the irrigated area is covered by paddy crops and both schemes adopt basin irrigation. In Goha, about 70% of the area is served by boarder strip irrigation and remaining 30% by furrows. In Yaqui, about 85.6% of the area is equipped with furrows and respectively 10%, 4% and 0.4% with border strips, overhead sprinkler and drip irrigation. Following the principle of upstream control, in all the schemes water flow in the main canals is continuous with variable supplies, except in Goha, where it is constant. The water distribution from the main canals to their branches is proportional and is then rotationally distributed to the respective lower level canals.

Figure 2 represents irrigation and drainage scheme layout in SMIS which is also valid for SRSIS. Water Courses (WC) are designed with same discharge capacity throughout and water is diverted in rotation from WC to the Field Channel (FC). Finally, water is distributed in equal proportion from the FC to the farms regardless of varying crop water demands across the farms. Such types of distribution are not amenable to flexible demands and supplies. In Yaqui the 2002-2003 cropping year was the driest year when the available water met only about 60% of the demand. Hence, the proportional distribution of water did not fit with the irrigation need. Therefore, variable water was supplied rotationally based on actual water requirements of the crops. It was possible due to the flexible structures of the irrigation scheme. In addition, different prioritizations could be made for the crops. Priority was given to the crops that required relatively less water, encouraged greater labour demand and

\(^{6}\) Full control surface irrigation supply is based on the principle of moving water over the land by simple gravity in order to wet it, either partially or completely, before infiltration (FAO, 2007). It can be either furrow, or border strip, or basin irrigation.
economic return, which would not be the case if not irrigated. Farmers were not allowed to select their crops to plant. Thus, the irrigation agency controlled the cropping patterns through planting permits. Such measures are hard to adopt in the SMIS and SRSIS because of the proportional water distribution structures and run of the river types schemes without reservoir for water acquisition.

Figure 2: Typical irrigation and drainage system layout in Sunsari Mornag Irrigation Scheme (Source: Koirala, 2004).

### 3.3. Organizational Structures

In Yaqui three main actors – government, the limited responsibility societies (Sociedad de Responsabilidad Limitada), and the WUAs – are involved in irrigation development and management, where the limited responsibility societies are in the middle and have the O&M responsibility for the main canals. The limited responsibility society committee consists of the presidents of the WUAs of each modulo that make up the district. Further, the limited responsibility society hires technical staffs to undertake its responsibility. This is not the case in the other three schemes where only two actors - government and WUA- are working together to run the scheme. The WUAs of Yaqui comprise of four layers, including one technical unit which consists of hired professionals to support the WUAs. This type of WUA can be called a business oriented association which gives an opportunity to hire skilled staffs. In the other three schemes, WUAs are fully social oriented organizations without any provision to hire technical staff.

All levels of WUAs involved in SRSIS, Goha and Yaqui are legally recognized and have autonomy. In SMIS there are four layers of WUAs, among them only two higher layers have legal recognition and no layer has autonomy (KC, 2008; SMIS, 1995). In every scheme the general assembly has the responsibility of electing and controlling the executive body, approving the annual O&M plan, yearly budget and irrigation service fee. To maintain transparency, the WUA reviews and endorses its annual programme of the general assembly.

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7 Modulos are the lower level water user’s organizations through which irrigation management is undertaken in Yaqui Irrigation District. In Yaqui Irrigation District there are 42 modulos.
and audits the accounts.

Technically and economically strong WUAs tend to make better use of the available land and water resources. For example, the prevailing productivities both in terms of land and water are the highest in the Yaqui which also has a solid WUA among the four schemes. In Goha, primarily due to a weak WUA, major maintenance of hydraulic structures, access road and main canal has not been carried out since the construction of the scheme. Farmers are not able to handle such works and, consequently, agricultural outputs are substantially below the potentials.

3.4. Responsibility Sharing for Operation and Maintenance (O&M)

SMIS and SRSIS are Jointly Managed Irrigation Schemes (JMIS). Accordingly, annual O&M is the joint responsibility of the agency and the farmer, whereas Goha and Yaqui are farmer-managed irrigation schemes (FMIS) where users are solely responsible for O&M. Therefore in Goha and Yaqui the concerning WUAs manage required O&M expenses for the entire scheme while in SMIS and SRSIS, WUAs manage the budget for the canal system below the secondary level and agencies do that from main canal to the secondary canal level.

3.5. Who Collects Irrigation Service Fee?

WUAs are entitled to collect irrigation service fee. The land-based charging system is being applied in all the schemes except in Yaqui where it is volume-based. In Goha and Yaqui, the entire collected irrigation service fee is retained and managed by WUAs, but in SMIS and SRSIS almost 50% of the collected fee goes to government treasury. This is one of the reasons of low fee collection in SMIS and SRSIS. Hence, these schemes cannot implement annual O&M activities without external support. Yaqui is the only scheme where such costs are charged to the farmers that they fully cover annual O&M expenses.

Comparatively, the situation is worst in SMIS where present fee collection is only about 12% of the target and covers merely 1.5% of the annual O&M costs. Even if the fees were fully collected they would not cover more than 12% of the O&M requirement. For example, in 2002/2003 silt removal from the settling basin could not be done due to lack of O&M fund and spare parts for dredges (Paudel, 2002). Consequently, the silt load in the canal system reached to about 354,000 m$^3$ from 118,000 m$^3$ in the previous year, almost three times more. If the situation is not solved in time, it will influence the scheme’s performance. Ultimately, canal delivery capacity would be reduced causing water stress in the crops and that would reduce the productivity.

3.6. Farmer’s Income in Relation with Irrigation Fee

The average land holdings in the studied schemes have great variations with a minimum of 0.4 ha in Goha and a maximum of 11.5 ha in Yaqui. Accordingly, per household incomes are found different (Table 1).

Table 1: Farmer’s income in the four selected schemes

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Units</th>
<th>SMIS</th>
<th>SRSIS</th>
<th>Goha</th>
<th>Yaqui</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>US$ha$^{-1}$</td>
<td>717</td>
<td>1424</td>
<td>1611</td>
<td>1137</td>
</tr>
<tr>
<td>Average land holding</td>
<td>ha</td>
<td>1.0</td>
<td>1.5</td>
<td>0.4</td>
<td>11.5</td>
</tr>
<tr>
<td>Total income</td>
<td>US$</td>
<td>717</td>
<td>2136</td>
<td>644</td>
<td>13076</td>
</tr>
</tbody>
</table>
The land distribution within the schemes is also different. In SRSIS, small land holders have less than 0.5 ha which concerns 40% of the farmers and large land holders have more than 2 ha which applies to 20%. In SMIS, the minimum and maximum land holdings are, respectively, less than 0.5 ha and more than 3 ha. Hence, it can be inferred that the small land holders of all schemes except Yaqui cannot survive on agriculture revenue alone. Nevertheless, in comparison to their irrigation fees annual incomes are far greater (Table 2). Still in all the schemes except in Yaqui farmers are not willing to pay the irrigation service fee.

Table 2: Affordability and willingness to pay in the four selected schemes

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Units</th>
<th>Name of the scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SMIS</td>
</tr>
<tr>
<td>Total income</td>
<td>US$</td>
<td>717</td>
</tr>
<tr>
<td>Irrigation service fee</td>
<td>US$ha⁻¹</td>
<td>2.9</td>
</tr>
<tr>
<td>Average land holding</td>
<td>ha</td>
<td>1.0</td>
</tr>
<tr>
<td>Total Irrigation service fee</td>
<td>US$</td>
<td>3</td>
</tr>
<tr>
<td>Irrigation service fee to income</td>
<td>%</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Hence, two key steps – designing a pricing mechanism and achieving high collection rates as recommended by the World Bank (2005) – seem essential to improve cost recovery. The designing involves working with the water supplier and farmers to determine appropriate costs. Achieving high collection rates involves autonomy and effective water management. According to the World Bank (2005), cost recovery is achievable by shifting irrigation scheme management to a financially autonomous organization. Similarly, effective water management enhances farmers’ income leading to an increased ability to pay irrigation service fees. In addition, a strong motivational tool that can convince farmers to pay their service charge to contribute for the sustainable irrigation development is equally important.

3.7. Land and Water Productivity

Disparate land productivities are found in the four irrigation schemes with a minimum of 717 US$ per ha in SMIS and a maximum of 1611 US$ per ha in Goha (Table 3). The results from FAO CropWat show that with the same irrigation supply it may be possible to increase current productivity per unit land of Goha by almost three folds and in Yaqui by a small margin of 5%.

Table 3: Current and potential productivities per unit land in the four selected schemes

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Units</th>
<th>Name of the scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SMIS</td>
</tr>
<tr>
<td>Current yield</td>
<td>US$ha⁻¹</td>
<td>717</td>
</tr>
<tr>
<td>Potential yield</td>
<td>US$ha⁻¹</td>
<td>1076</td>
</tr>
<tr>
<td>Net increment</td>
<td>%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Productivities per unit water also varied with irrigation schemes with a minimum of 0.10 US$ per m³ in SMIS and a maximum of 0.20 US$ per m³ in SRSIS (Table 4). CropWat results show that production per unit water in Goha can be increased by three folds and in Yaqui by a small margin of 14%. This implies that the prevailing productivity of Goha is far
below the potential and in Yaqui it is close to the potential. Thus, Goha shows the biggest prospect in terms of improving productivity. Variations in land and water productivities reflect the differences in the capacities to exploit potentials from available land and water resources. Nevertheless, it should be noted that water alone is not the decisive factor for a good performance in agriculture.

Table 4: Current and potential productivities per unit water in the four selected schemes

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Units</th>
<th>Name of the scheme</th>
<th>SMIS</th>
<th>SRSIS</th>
<th>Goha</th>
<th>Yaqui</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current yield</td>
<td>US$m m^{-3}$</td>
<td>0.10</td>
<td>0.20</td>
<td>0.11</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Potential yield</td>
<td>US$m m^{-3}$</td>
<td>0.14</td>
<td>0.29</td>
<td>0.32</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Net increment</td>
<td>%</td>
<td>40%</td>
<td>45%</td>
<td>191%</td>
<td>14%</td>
<td></td>
</tr>
</tbody>
</table>

3.8. Food Scarcity Situation in the Countries of the Four Selected Schemes

A study carried out in one part of a country might not represent other parts with different ecological conditions. Hence, for the analysis purpose only the irrigated areas that are located within the same ecological zone of the selected irrigation scheme was considered. Ecologically Nepal is divided into three regions – the Plain region, the Hill region, and the Mountain region. The plain region, where SMIS is located, is the most suitable area for cultivation. Total irrigated area of the Plain region is 926,000 ha (Department of Irrigation, 2005). Then assuming the same irrigation intensity and cropping pattern in the whole plain region and using the same climatic potential productivity as in SMIS, the potential production can be for cereal 7.3 million ton for the irrigated area of the Plain region. Similar estimations were also made for the schemes in the other countries.

Table 5 summarizes per capita calorific values based on the potential cereal production compared with the minimum calorie requirement estimated by FAO (2015). The results show that at country level food scarcity would occur only in Ethiopia if potential cereal production was achieved. In the other three countries, there would be enough food to meet the requirements.

Table 5: Calorie estimate based on potential cereal production in the four countries in Kcal per head per day

<table>
<thead>
<tr>
<th>Countries</th>
<th>Potential calorie</th>
<th>Minimum Calorie requirement</th>
<th>Calorie surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>1646</td>
<td>1720</td>
<td>-74</td>
</tr>
<tr>
<td>India</td>
<td>2419</td>
<td>1820</td>
<td>599</td>
</tr>
<tr>
<td>Nepal</td>
<td>3866</td>
<td>1810</td>
<td>2056</td>
</tr>
<tr>
<td>Mexico</td>
<td>2761</td>
<td>1900</td>
<td>861</td>
</tr>
</tbody>
</table>

However, based on minimum calorie need FAO (2015) has identified a significant proportion of undernourishment in countries under study except in Mexico (Table 6). For example, in the 2014-16 periods, there were 195 million undernourished people in India which equals 15% of the country’s population of 2015. Similarly there were, respectively, 2.2 and 31.6 million undernourished people in Nepal and Ethiopia, which were correspondingly 8% and 32% of their population. In Mexico food scarcity situation was not significant (<6 million which is <5% of country’s population). However, food scarcity may also be due to other reasons such as poor access to food rather than food shortage.
Table 6: Number of people undernourished (millions) in the four countries as estimated by FAO

<table>
<thead>
<tr>
<th>Periods</th>
<th>Ethiopia</th>
<th>Nepal</th>
<th>India</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-92</td>
<td>37.3</td>
<td>4.2</td>
<td>210.1</td>
<td>6.0</td>
</tr>
<tr>
<td>2000-02</td>
<td>37.3</td>
<td>5.2</td>
<td>185.5</td>
<td>not statistically significant</td>
</tr>
<tr>
<td>2005-07</td>
<td>34.3</td>
<td>4.1</td>
<td>233.8</td>
<td>not statistically significant</td>
</tr>
<tr>
<td>2010-12</td>
<td>32.1</td>
<td>2.5</td>
<td>189.9</td>
<td>not statistically significant</td>
</tr>
<tr>
<td>2014-16</td>
<td>31.6</td>
<td>2.2</td>
<td>194.6</td>
<td>not statistically significant</td>
</tr>
</tbody>
</table>

4. Socio-Economic Impact

Population growth, environmental consciousness, urbanization, industrialization, economic development, and geopolitics are some of the crucial influencing factors affecting people’s everyday life in the world today (KC, 2008). These demographic changes and socioeconomic developments are creating a huge pressure on already stressed fresh water and agricultural land, resulting in reduced per capita availability of land and water resources (Schultz et al., 2009). Compressing land and water resources and expanding world population are posing serious challenges to increase current land and water productivity to cope with the rising food demand (FAO & ICID, 2014; Schultz et al., 2007).

Improvement in irrigation water management leads to increased cropping intensity resulting in increased overall production, productivity levels per unit of land and water, and eventually farmers’ gross income (National Planning Commission Secretariat, 2012). Institutional and technological improvement in irrigation schemes means increase in land and water productivity (Goklany, 1998). In this line of discourse, various researches have been conducted, including investigations that looked into variations in experience between developed and developing country groups. KC et al. (2011), for example, reviewed irrigation management at global scale by dividing the developing country group into two subgroups of emerging and least developed countries based on the internationally accepted classification. The findings of the study were insightful for improving water management in order to increase sustainable food production to eliminate hunger and poverty in the least developed and emerging countries.

In the same vein, this study reviewed institutional and technological measures adopted in the four irrigation schemes selected from the least developed and emerging countries to find out the gaps between the potential and existing productivity using FAO CropWat 4. The findings show that there are promising possibilities for increasing current land and water productivity levels in the studied schemes. In the least developed countries like Ethiopia, farmers’ current income can be increased by almost three folds. Also in the emerging countries, proper irrigation management will have a huge positive impact. The outcome of the study will help improve socio-economic status in both the least developed and emerging countries where majority of the population rely on land and water for their livelihood (Hofwegen & Svendsen, 2000).

There is a strong positive link between irrigation, poverty alleviation and food security because for many rural communities, agriculture is the main source of livelihood (United Nation, 2006). Therefore, improvement in agriculture is a prerequisite to alleviate poverty in the rural areas. Realizing the same, UN Hunger Task Force 2004 made first recommendation to increase food production in order to alleviate hunger and poverty. Therefore, of the eight Millennium Development Goals (MDG), eradicating extreme hunger
and poverty reduction is one of them which heavily depends on agriculture (Donoso and Cansino, 2010). These objectives have been followed up by the Sustainable Development Goals (SDG) beginning 2015 (United Nations, 2015).

Needless to say, poverty alleviation is closely linked to improved production and productivity levels (Van Koppen, 1998). In Africa, for example, 10% increase in agricultural productivity may reduce the poverty by 7%. In India, a similar increase in productivity can decrease the poverty by 4% in the short-run and 12% in the long run. Irrigation development creates direct job opportunities in the field of irrigated agriculture and indirect jobs in the areas that are linked with agricultural businesses. Besides employment generation and food security, irrigated agriculture also contributes to social harmony. Thus irrigation improves the well-being of rural poor. In a broad sense, increasing productivity in agriculture means deriving more benefits and alleviating poverty, at least in the short-run. Increased agricultural productivity allows people to break out of the poverty-hunger trap.

The risk of not maintaining a productive agriculture is a strategic mistake (Bakker et al., 1999). Hence, institutional and technological improvements are a prerequisite to amplify the food production in order to meet the increasing demand of the regions, and thereby help alleviate global hunger and poverty (FAO & ICID, 2014; KC et al., 2011; Schultz et al., 2009).

5. Conclusion

This study, based on the findings outlined below, suggests that a combination of institutional and technological improvements in the existing irrigation and drainage schemes can contribute significantly to the increase in current productivity levels, both in the least developed and emerging countries.

One of the main factors contributing to poor performance is the lack of suitable and effective water control structures in the irrigation canal. Proportional water distribution inside the tertiary units works only if there is enough water in the scheme and crop water demand is uniform across the farms. It cannot address the changing crop water demand due to its proportional division boxes. In such cases if water is limited in the scheme, it would create water stress on all the crops of the command area.

Rotational water distribution does not encounter such limitations. In addition, different prioritizations are possible in rotational supply. Therefore, in Yaqui irrigation supply was made rotational in 2002-2003 when the available water met only about 60% of the demand. It was possible due to flexible water control structures of the irrigation scheme. Consequently productivities are higher in Yaqui compared to the other schemes. Such measures are not feasible in the schemes with proportional division boxes, like in SMIS, SRSIS and Goha.

In comparison to JMIS, revenue collection performances are superior in FMIS. For example, in Goha and Yaqui, annual fee collections are, respectively, 72% and 100% of the target, while in SMIS it is hardly 11%. In SMIS and SRSIS, annual irrigation fees are not sufficient to cover the O&M cost. Even if the irrigation service fee is fully recovered, it would cover only 12% and 70% of O&M requirements of the respective schemes. Consequently, annual maintenance plans are deferred at the cost of the level of irrigation service. This has great influence in the scheme’s sustainability.

The results show that in the least developed countries prevailing productivities are substantially below the potentials. For example, in Goha which falls under the group of the least developed countries, the present economic productivity per unit irrigated area is almost
200% below the achievable limit, while in Yaqui, which is classified as an emerging country, it is just about 5%. This implies that more attention can be paid to improving land and water productivities of the existing schemes in the least developed countries.

Clearly defined water use rights and their effective implementation promote uniformity in irrigation supply, resulting in higher production. Tradable water use rights create opportunities for the users to buy water from nearby farmers which increases the reliability. Consequently, in the schemes with clear provision of water use and tradable water use rights the productivity levels are comparatively higher.

References


KC, B., Schultz, B., & Prasad, K. (2009). Contribution of institutional and technological improvement to land and water productivity, which is the original paper based on which this paper has been developed. 5th Asian regional conference. New Delhi, India.


