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CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

# Sustainable Financial Solutions for the Adoption of Solar Powered Irrigation Pumps in Nepal's Terai

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## Executive Summary

Solar powered irrigation pumps (SPIPs) are a proven technology, and can potentially be a game changer in Nepal's irrigation sector by providing clean irrigation to millions of farmers. However, the relatively high capital cost of SPIPs is the main impediment that prevents large scale adoption of SPIPs. Given this, can we design appropriate financial solutions that will help in the large scale adoption of this clean and efficient technology? We ran a randomized experiment in order to estimate demand for SPIPs under three financial models – 'grant'; 'grant-loan' and 'grant-pay as you go' in Saptari district of Nepal. We provided an additional 10% discount to women applicants, provided they owned the land on which SPIPs were to be installed. These models were based on policies of the Alternative Energy Promotion Centre (AEPC), and similar schemes available in India and Bangladesh. Village Development Committees (VDCs) were randomly divided into three groups and one financial option was provided to each group of VDCs. This randomized control trial (RCT) helped estimate absolute demand for each of the models. We ran 45-days promotional campaigns to solicit demand from farmers. The main findings from our experiment were:

- Promotion campaigns need to be carefully crafted to reach out to a maximum number of potential customers.

- There is a high demand for SPIPs in the Terai region of Nepal. We received 65 applications from Saptari district. This is a significant number given that there are no more than 15-20 SPIPs in Nepal right now, and all of these are pilot demonstrations by NGOs.
- Giving additional discounts to women farmers can lead to a lessening of structural inequities in land ownership. 77% of our applicants were women. For them to avail of the special women's discount, land on which the SPIPs were to be installed had to be transferred to women – either solely, or jointly with any other male family member. We found, in 82% of the cases, land has already been transferred to the woman applicant.
- Giving a one-time grant is not enough for a high cost farm equipment like SPIP. Loans and pay as you go options are also needed. We found that 20% of demand was for the grant model, 46% for the grant-loan model, and 34% for the grant-pay as you go model.
- There is a viable business opportunity for solar entrepreneurs in rural Nepal to rent out SPIPs to farmers against rental fees as a part of the grant-pay as you go model. But this can happen only if private companies can directly avail of SPIP grants from the government of Nepal.
- Group ownership of irrigation assets is not a preferred market model, and only one out of 65 applications was from a group. This makes it important to re-think usual government grant policies that target groups instead of individuals, often under misplaced equity concerns. Group models, intermediated by reputable NGOs, however, may be tried out for reaching out to smallholder and marginal farmers who do not yet practice intensive irrigated agriculture.
- Farmers who have applied for SPIPs have more land, better access to irrigation and own more pumps on average. This shows farmers who are already practising irrigated agriculture are more likely to demand SPIPs under the market models that we offered. For reaching out to smallholder and marginal farmers, non-market models like NGO ownership should be explored – something we did not do in our study.

## Introduction and Problem Statement: Water Scarcity Amidst Plenty

Water issues in the eastern parts of the Hindu Kush Himalaya (HKH) can be summed up in the form of a paradox: 'scarcity amidst plenty'. This region, comprising of eastern Nepal and the eastern parts of the Indo-Gangetic plains in India and Bangladesh, receives plenty of rainfall. It also has good groundwater potential, of which only a small proportion has been exploited. Yet, farmers in the region face severe agricultural water scarcity due to lack of affordable energy for pumping groundwater. There is a lack of canal infrastructure, and even when there are canal networks, water services are poor and unpredictable. Given the shallow depth of groundwater and the ease of constructing shallow tube wells, farmers depend on groundwater for irrigation. Since electricity is not available in much of the rural areas, farmers resort to diesel pumps for pumping groundwater. The entire eastern Indo-Gangetic region has about 5-8 million diesel pumps according to various estimates (Shah, Singh and Mukherji, 2005). However, diesel is not only expensive, but also dirty in that it emits large quantities of black carbon and other short lived climate pollutants. Farmers therefore irrigate only sparingly, and instead, depend largely on the monsoon. And when monsoons fail, they suffer from crop loss, and overall food security is compromised. Most of these areas grow a single crop in a year and farmers leave land fallow in the winter and summer. This phenomenon of water scarcity amidst physical plenty is called 'economic and institutional water scarcity' (Molden, ed. 2007).

Nepal's southern plains, also called the Terai, are symptomatic of this 'water scarcity amidst abundance' paradox. The Terai is the food basket of Nepal, accounting for 71% of paddy, 64% of wheat and 58% of total vegetable production (CBS, 2014). But productivity of all crops is lower than the regional average. For example, in the Terai, rice productivity is only 3.39 t/ha, compared to 4.4 t/ha in Bangladesh (ricepedia.org hosted by IRRI). Average land holding is 0.7 hectares and cropping intensity is only 186% (CBS, 2015) – which means that land is kept fallow in

much of winter and the whole of summer. Here, 74% of land is under irrigation, mostly canal irrigation (CBS, 2015). However, service is poor and farmers do not get water during the dry season. Groundwater irrigation offers a viable alternative. Nepal's Terai has an estimated renewable dynamic groundwater reserve of 8,800 million cubic meters (MCM) of which only 1,053 MCM (11%) has been tapped so far (Nepal Groundwater Resources Development Board, 2016). Groundwater is available at shallow depths of 5-15 m below ground level. Currently, only 20% of holdings in the Terai utilize shallow tube well for irrigation, and 30% have pumping sets (CBS, 2011). An oft quoted reason for such low groundwater utilization is energy scarcity – electricity supply is unreliable, and diesel costs are high.

## Solar Powered Irrigation Pumps as a Clean Energy Solution in Nepal's Terai

Are there technological alternatives that will enable small holder farmers to grow more crops in one year by utilizing abundant groundwater without polluting the environment? Solar powered irrigation pumps (SPIPs) provide one such alternative. SPIPs have been tested widely in the region and have been found to be a technically proven and workable solution for all categories of farmers – men and women. ICIMOD installed three one horse power (HP) SPIPs in Saptari district of Nepal in August 2015. Cumulatively, these three SPIPs have been operated for 1,575 hours from August 2015 to November 2016 (Figure 1), and irrigated 17.3 ha of land compared to 13.1 ha in 2014-2015 when irrigation was done using diesel and electric pumps. Yearly savings in diesel amount to more than USD 1,000. Overall, the gross and net irrigated area rose by 25% and 30% respectively. We also noted an increase in the cultivation of dry season vegetables, and a doubling of the number of water users, from 15 to 31. These pumps were installed for demonstration purposes and generated huge interest among farmers in Saptari, leading to several enquiries for purchasing these pumps.

Figure 1: **Volume of water ('000 litres) and hours of use for 3 SPIPs demonstrated in Saptari district by ICIMOD**

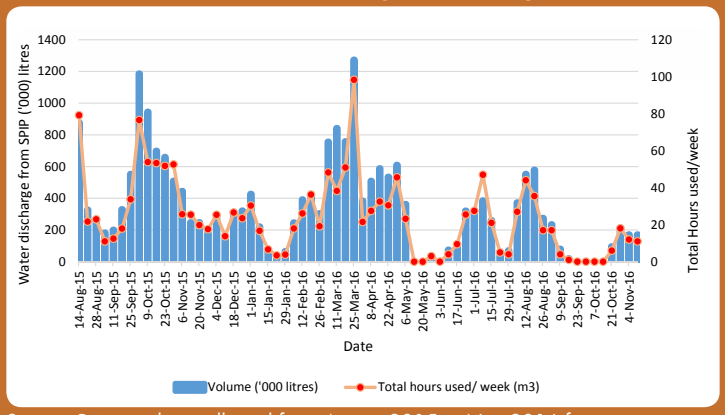
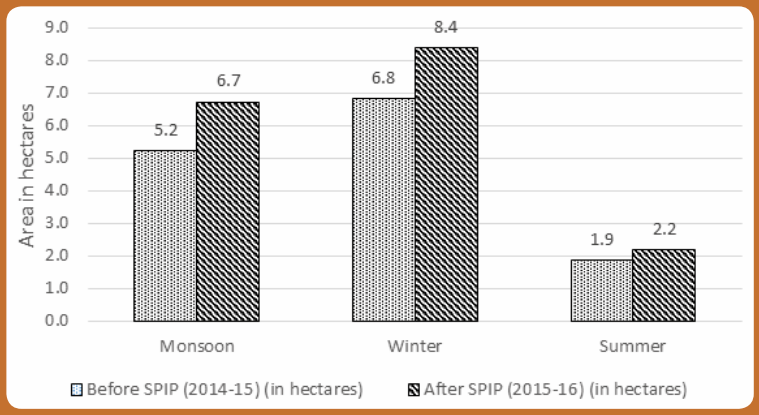



Figure 2: **Area under irrigation, before and after installation of SPIP**




Source: Primary data collected from August 2015 to Nov 2016 from three SPIP demonstration sites

## Research Question: How can we Sustainably Finance SPIPs for Smallholder Farmers?

The relatively high costs of these pumps – the cheapest 1 HP (1,200 kilowatt peak) pump costs around USD 3,800 per system – means that SPIPs are not easily affordable for smallholder farmers. All countries in South Asia provide different financial incentives, like subsidies and loans for the uptake of SPIPs. However, existing literature shows that the uptake of SPIPs is limited to richer farmers due to the way subsidies are administered leaving smallholder farmers, men and women, outside the ambit of the benefits of subsidies given by the government. Is there any way of providing financially sustainable options for the adoption of SPIPs for small holder farmers (both men and women) in ways that are robust and can be replicated elsewhere? The research question that we ask is: What is the demand for SPIPs under different financial packages for men and women, especially when additional financial incentives are provided to women farmers?

## Financial Models

We offered three financial models – a grant model where a 60% grant was offered, and the remaining cost of the SPIP was borne directly by the farmers; a grant cum loan model where in addition to the 60% grant, 20% of the total cost was provided as loan at a 5% interest rate and the remaining 20% had to be paid upfront; and a pay as you go model where farmers do not have to pay any upfront amount, and instead pay a monthly or seasonal rent for using the pump, and having payed that rent over a three-year period, will eventually own the pumps (see Table 1 for details). In the pay as you go model, the grant is availed by an entrepreneur who then rents out the equipment to the farmer.

Due to high male specific outmigration, women manage much of the agriculture in Nepal. Yet, they do not own land or productive assets. We designed our financial schemes in ways that gave additional 10% discounts to women farmers provided they owned the land. Rental amount in the pay as you go model is calculated based on whether the renter is a male or a female farmer. Our hypothesis is that this will incentivize male family members to transfer land to women family members in order to avail the additional discount and in the process, structural inequity in land holding will be partially addressed. The total cost for the pump is NPR 380,000 (USD 3,478). Table 1 shows the actual amount that farmers have to pay under different financial models.

Table 1: **Details of financial packages available to farmers in Saptari district**

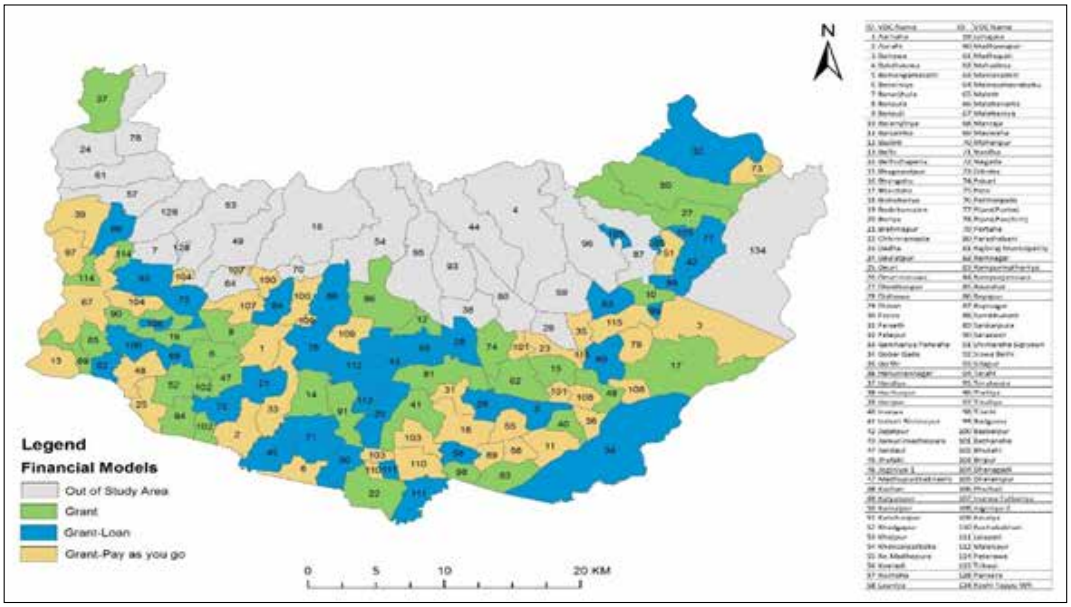
| Financial model | Upfront cost (in NPR) | | Monthly Instalments (in NPR)* | |
|---|---|---|---|---|
| Category of farmers | General | Female | General | Female |
| Grant | 152,000 | 114,000 | 0 | 0 |
| Grant-loan | 76,000 | 57,000 | 2,300 | 1,750 |
| Grant-pay as you go | 0 | 0 | 4,600 | 3,500 |

* To be paid over 3 years at an interest rate of 5% per annum

## Randomized Control Trial (RCT) for Determining Demand for SPIPs

Our objective was to measure the absolute demand for each of the financial models when no other model was being offered. Offering all the models simultaneously would have led to self-selection of farmers without allowing us to determine absolute demand, or to understand what kinds of farmers demand what types of financial models. This required a randomized evaluation approach. "A randomized evaluation is a type of impact evaluation that uses random assignment to allocate resources, run programs, or apply policies as part of the study design. Like all impact evaluations, the main purpose of randomized evaluations is to determine whether a program has an impact, and more specifically, to quantify how large that impact is. Impact evaluations measure program effectiveness typically by comparing outcomes of those (individuals, communities, schools, etc.) who received the program against those who did not". (https://www.povertyactionlab.org/research-resources/introduction-evaluations). We randomly divided 93 eligible VDCs of Saptari into three categories and each of these groups of VDCs were offered only one financial model. While Saptari has 114 VDCs, 21 VDCs were not eligible for any financial model given that they have limited groundwater availability as per the data from Nepal's groundwater department (Figure 3).

Figure 3: **VDCs in Saptari that received three different financial models as a part of the RCT experiment**




## MAIN FINDINGS

### Promotion Campaigns Need to be Carefully Crafted to Reach out to a Maximum Number of Potential Customers

Two types of promotional campaigns were carried out. First, we conducted targeted model specific information campaigns in Rajbiraj – the district HQ of Saptari. Here, we demonstrated the functions of SPIPs. A two-hour session followed, where features of SPIPs and the financial models being offered were explained. Thirty-three demonstration and orientation campaigns were conducted over the course of 27 days, with representatives from all 93 VDCs participating. One social mobiliser from each VDC brought 1,989 farmers to the district HQ. Social mobilisers are quasi-government employees whose job is to disseminate information about various developmental schemes to people in their respective VDCs.

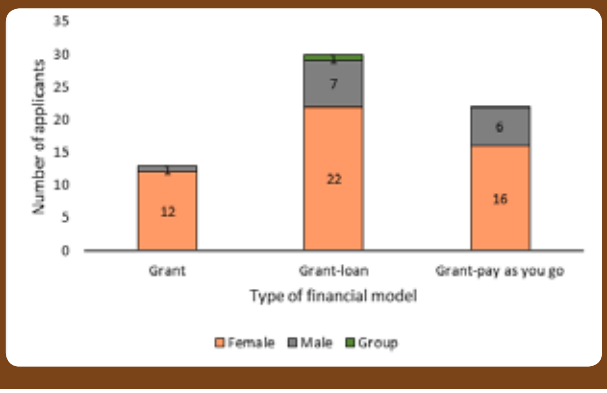
Second, we conducted generic information campaigns through radio broadcasts and advertisements in all major local newspapers. We also distributed pamphlets in 30 local markets (hattiyas). Radio jingles were played five times a day in five local radio channels for 20 days, and newspaper advertisements were published in seven local newspapers for 15 days. In these generic information campaigns, we did not provide details of each of the financial schemes as it was not possible to target the information to the right group. Instead, we provided the names and addresses of the social mobilisers in their respective VDCs, and the contact information of our partner NGO, Sabal Nepal. Farmers could get information on the financial scheme for which they were eligible from these sources. Table 2 shows the number of farmers we reached through two means: model-specific targeted demonstration cum promotion campaigns, and information campaigns

Table 2: **Type of information campaign, and farmers reached**

| Type of information campaign | # Sessions | # of male participants | # of female participants | Total participants |
|---|---|---|---|---|
| Demonstration cum information campaign in district HQ | 33 | 1,388 | 601 | 1,989 |
| Information campaign in hattiyas | 30 | 561 | 43 | 604 |
| Enquiry through phone calls | NA | 62 | 4 | 66 |
| Total | 63 | 2,011 | 648 | 2,659 |

Source: Primary data collected from August 2016 to October 2016

Figure 4: **Number of applications received for different financial models**




in hattiyas. It also shows the number of farmers who contacted the Sabal Nepal office after hearing about our schemes through channels like radio and newspaper advertisements (Table 2). We reached out to 2,659 farmers in Saptari, of which 24.4% were women.

We found that 95% of the demand came from farmers who had viewed SPIP demonstrations and were given face to face orientation. The rest came from those who had heard of SPIPs from promotional channels like radio, newspapers and hattiyas.

## There is High Demand for SPIPs in Nepal's Terai

By the end of nearly two months of an intensive demand collection exercise, we received 65 applications for SPIPs. This is not an insignificant number from a single district, given that only 15-20 SPIPs are operational in Nepal right now, and these as demonstration pilots set up through NGOs and developmental organizations like Winrock, IDE, and ICIMOD. This is the first instance of systematic demand determination for SPIPs in Nepal, and it bodes well for Nepal's renewable energy sector. Figure 4 shows the number of applications from women and men farmers and farmers' groups for three financial models.

## Giving Additional Discounts to Women Farmers can Lead to a Lessening of Structural Inequities in Land Ownership

About 77% of all applications came from women farmers. This shows that the need to transfer legal ownership of land to women was not seen as an impediment to availing additional discount. Indeed, we found that in 82% of the cases where women had applied, land has been already transferred to them. We were assured by the remaining women applicants that they would also get land transferred to them (either solely or jointly with another family member) before SPIPs are installed on their land. This is an important finding as it shows that it is possible to reduce structural inequities in land ownership through innovative public policy interventions.

## A Subsidy is not Enough for a High Cost Farm Equipment like an SPIP, Loans and Pay as you go Options are also Needed

Our hypothesis was that there will be least demand for the grant model, and high demand for the grant-loan and grant-pay as you go model. This turned out to be correct. Of the 65 applications, 13 (20%) were for the grant model, 30 (46%) for the grant-loan model, and 22 (34%) for the grant-pay as you go model. However, belying our expectations, more applications came in from the grant-loan model than from the grant-pay as you go model, even though the former entails an upfront payment of NPR 57,000 (for female farmers) and 76,000 (for male farmers). In the later, there is no upfront payment, but per month payments are exactly double – NPR 4,600 for male farmers, and NPR 3,500 for female farmers.

### There is a Viable Business Opportunity for Solar Entrepreneurs in Rural Nepal

However, that grant-pay as you go model still generated 34% of the total demand. This shows that the model is deemed useful by the farmers. Under this model, an entrepreneur gets the grant and then rents out the equipment against a monthly rental fee. This shows that there is scope for private players to get involved and offer solar irrigation services as a commercial enterprise, provided they can directly avail the grant needed from the government of Nepal.

### Group Ownership of Irrigation Assets is not a Viable Market Model

Of the 65 applications, only one application was from a group, showing that the majority preferred to apply as single applicants. This runs against the common practise of most government schemes which prefer a community/ group ownership model for equity purposes. Very often, those community schemes do not work due to issues of collective action. Our experiment shows, that given a choice, farmers prefer owning assets individually, even when they can share costs when in a group. This is because they perceive the transactional costs of group ownership to be much higher than the benefits that they may get.

### Farmers who have Applied for SPIPs have More Land, Better Access to Irrigation and own More Electric Pumps on Average

Our preliminary results show that farmers who have applied for SPIPs tend to have more land (1.85 ha) than those who came to the orientation meetings but did not apply (0.9 ha). However, of all the applicants, 30% are still smallholder farmers with less than 1 hectare of land. Table 3 sums up the differences among farmers who applied, farmers who collected forms (but did not apply), and farmers who came for orientation meetings but did not collect forms nor apply. It shows that farmers who applied tend to have more land, are more likely to use groundwater for irrigation, and more likely to own electric pumps than those who did not apply. However, they do not seem to own more diesel pumps than others. This is somewhat contrary to our initial expectation where we had supposed that SPIPs would likely replace diesel pumps rather than electric pumps due to the associated high cost of operation.

It is evident that if we want to target SPIPs at the poorest of the poor, none of these models will yield desired results. A better alternative could be intervention by an NGO which provides access to SPIPs as part of a welfare scheme. However, our market based models work for all those farmers who are already invested in irrigated agriculture and want to reduce the long term costs of irrigation.

Table 3: **Characteristics of farmers who applied for SPIPs versus those who did not apply**

| Characteristics of farmers | Farmers who attended orientation but did not collect form | Farmers who collected application forms but did not apply | Farmers who applied |
|---|---|---|---|
| Number of farmers | 1,191 | 736 | 65 |
| Average area of plot (in hectares)[1] | .9[a] | 1.3[b] | 1.8[cd] |
| % Using ground water for irrigation | 50[a] | 60[b] | 66[cd] |
| % Owning diesel pumps | 43[a] | 49[a] | 45[aa] |
| % Owning electric pumps | 15[a] | 21[b] | 39[cd] |

The letters in superscript denote testing at a 1% level of significance. If the letter between two columns is different, we can reject the null hypothesis that the mean of the adjacent series are the same. For the third column, the first letter implies test with the first column, while the second letter implies test with the second column. Again a change in letters implies that we can reject the null hypothesis that the series mean are the same at a 1% level of significance. Source: Primary data collected during promotional campaigns from August to October 2016.

### There is no Significant Difference Among Farmers who Applied for Different Financial Models

One of our preliminary hypotheses was that farmers applying for the grant model would be better off than those applying for the grant-loan model, while farmers applying for the grant-pay as you go model would be smaller farmers. However, our data belied our expectation and we found that there is no significant difference among these groups in terms of assets, land ownership and irrigation indicators (Table 4). We will conduct further in-depth qualitative assessment to understand why it was so.

Table 4. Comparison of characteristics of farmers' who applied for the grant, grant-loan, and grant-pay as you go models

Table 4: **Comparison of characteristics of farmers' who applied for the grant, grant-loan, and grant-pay as you go models**

| Characteristics of farmers | Grant | Grant -Loan | Grant- pay as you go |
|---|---|---|---|
| % of applicants with modern houses | 80[a] | 65[a] | 69[aa] |
| Households asset score (out of 13) | 6.8[a] | 7[a] | 6.9[aa] |
| Livestock score (out of 8) | 3.3[a] | 4[a] | 3.5[aa] |
| Agriculture implements score (out of 5) | 1.7[a] | 1.5[a] | 2.3[aa] |
| Average number of bore wells owned | 1.58[a] | 1.38[a] | 1.95[aa] |
| Average number of electric pumps owned | .83[a] | .69[a] | 1.19[aa] |
| Average number of diesel pumps owned | .5[a] | .3[a] | .95[aa] |
| Average number of CD pumps owned | .33[a] | .34[a] | .85[aa] |
| Average land holdings (in hectares) | 2.72[a] | 2.79[a] | 3.95[aa] |

The letters in superscript denote testing at a 1% level of significance. If the letter between two columns is different, we can reject the null hypothesis that the mean of the adjacent series are the same. For the third column, the first letter implies test with the first column, while the second letter implies test with the second column. Again a change in letters implies that we can reject the null hypothesis that the series mean are the same at a 1% level of significance.

Source: Baseline survey conducted in November 2016 for all 65 farmers who applied for SPIPs

## The Way Forward

The next step is installation. We have conducted technical and financial feasibility surveys and found that all except three farmers qualify, and will install 62 SPIPs in January 2017. SPIPs will come with automated data monitoring systems that will enable us to monitor the functioning of pumps and also disable them should farmers default repayment of loan or rental fees. We have already conducted a baseline survey for all farmers who have applied for SPIPs. We will also conduct mid line and end line surveys (qualitative and quantitative) and capture the impact of these SPIPs on agricultural and livelihood outcomes like cropping intensity, cropping pattern, crop productivity, incomes and nutritional intake.

## References


Central Bureau of Statistics (2011). *Nepal Living Standard Survey 2010/11*, Kathmandu: Central Bureau of Statistics.

Central Bureau of Statistics (2014). *Statistical Information on Nepalese Agriculture 2013/14*, Kathmandu: Central Bureau of Statistics.

Central Bureau of Statistics 2015. *Statistical Pocket Book of Nepal 2014*, Kathmandu: Central Bureau of Statistics.

David, M. (Ed.). (2007). *Water for food, water for life: a comprehensive assessment of water management in agriculture*. London: Earthscan, and Colombo: International Water Management Institute.

Groundwater Resources Development Board. (n.d.). Retrieved from http://www.gwrdb.gov.np

International Rice Research Institute. (2016). *Ricepedia: the online authority on rice*. Retrieved from http://ricepedia.org

Shah, T, Singh, O.P. & Mukherji, A. (2006). 'Groundwater irrigation and South Asian agriculture: Empirical analysis from a large scale survey of India, Pakistan, Nepal and Bangladesh', *Hydrogeology Journal* 14(3):286-309.



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This work was produced under the CGIAR Research Program for Water, Land and Ecosystems Ganges Regional Program

ICIMOD gratefully acknowledges the support of its core donors: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Switzerland, and the United Kingdom.





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