Laser levelling in Cambodia - from research to private sector implementation

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ABSTRACT

Better management and uniform application of water offers the potential to increase the efficiency of rice based farming systems in Cambodia. This paper presents results from an ACIAR project which looked at investigating and quantifying the benefits of laser levelling on rice crop yields and developing a private sector industry to offer these services. In summary, the project has been able to demonstrate the benefits of laser land levelling using both farm scale and district scale approaches. These have indicated a likely average increase in yield of approximately 20% on dry season rice yields. Additionally, weed control is dramatically increased and water management becomes more precise. Successful private industry laser levelling providers have been established in Cambodia and it is hoped this number will grow in time as the technique becomes more widespread and benefits seen by other farmers. At present however the technique is still seen as expensive by farmers. In order to overcome this hurdle, policies that allow this technology to be implemented, such as farmer subsidies for laser levelling, would assist in further kick-starting the industry. Increased yields are not the only benefits anticipated. Water savings arising from less water applied to laser-levelled fields have the potential to be redirected into more irrigated rice area and its associated production outcomes.

INTRODUCTION

Rice is consumed by approximately 3 billion people across the globe and is the most common staple food. Globally, population growth, rising incomes and urbanization are increasing the demand for water from the household and industrial sectors. Increased demand for water from these sectors and concerns about food security has increased the need for water in rice production systems to be reduced and water productivity increased. These factors have led to a growing interest in intensification through irrigation as a way to increase food production (Wokker et al, 2011). A further threat to food production is the uncertainty of climate change (Mainuddin and Kirby, 2009).

As in other countries, drivers of water demand (population growth, rising incomes and urbanisation) are present in Cambodia (Wokker et al, 2011). The Cambodian population is expected to increase from the current 14.8 million (CRDI, 2012) to between 20.4 and 27.4 million by 2050 (ADB, 2010). Although Cambodia is one of the poorest countries in the world, it simultaneously experienced a strong record of economic growth that averaged 8.4% between 1994 and 2008 (CRDI, 2012).The projection for economic growth is approximately 7% annually for the next 3 years.

Irrigated agriculture in Cambodia is responsible for approximately 90% of total water abstractions, (MOWRAM, 2009). In 2010, approximately 2,795,892 ha were under rice cultivation. Even though yields per ha are higher in dry season rice crops, these systems constitute only about 20 percent of the total area. Average rice yield in 2010 was 2.76 tonnes per ha in the wet season and 4.2 tonnes per ha in the dry season (MAFF 2011). With rice farming traditionally being dependent on rainfall, the majority of lowland farmers grow just one crop a year.

Better management and uniform application of water offers the potential to increase the efficiency of rice based farming systems in Cambodia. This paper presents results from an ACIAR project which looked at investigating and quantifying the benefits of laser levelling on rice crop yields and developing a private sector industry to offer these services.

METHODS

Three integrated phases were undertaken within the project to establish laser levelling within Cambodia. These were:

- Intensive on-farm research trials to quantify likely impacts from laser land levelling
- Outscaling laser levelling to demonstrate the technology to farmers across multiple areas and investigate impacts on yields at the district level
- Establishing private sector laser levelling service providers to ensure long term uptake into the future

Intensive on-farm research trials

Three farmer fields were used for experimental research demonstrations in the Takeo province. Farmers were selected based on community consultation. The field demonstration experiments consisted of laser levelling the demonstration paddies and leaving a remaining non-laser levelled area which could be used to collect comparison data with the same farmer management applied over both areas.

The demonstrations and experiments were re-measured following ploughing and levelling to identify any evenness following leveling. A second ploughing was conducted before planting. For the non-level treatment, the field was ploughed twice than harrowed before the crop was planted.

The Wet Season (WS) rice variety used was Phka Romduol, the Dry Season (DS) and Early Wet Season (EWS) rice variety used was Chul'sa. The rice was planted by Drum seeder (wet seed) and dry seeding machine. The DS and EWS seed rate was 150kg/ha and WS seed rate 80kg/ha. The weed control used contour and manual weeding. The crop emergence was measured, amount of water supplied, weed biomass and rice grain yield.

Outscaling laser levelling

Prior to the project there was no experience or capacity for undertaking laser land levelling in the Ministry of Water Resources and Meteorology (MOWRAM). MOWRAM is leading irrigation development and also rehabilitation of irrigation areas in Cambodia. In order to develop this capacity the Technical Services Centre (TSC) in MOWRAM went through a program of gaining the necessary skills to allow MOWRAM to undertake Laser Land Levelling as part of irrigation area rehabilitation programmes.

Steps involved in this process of knowledge transfer between project partners and MOWRAM TSC involved:

Constructing a laser levelling bucket in Cambodia

Design of the laser levelling bucket was based off earlier designs by Rickman (2002). The equipment was constructed by a local Engineering firm based in Phnom Penh specialising in agricultural implement construction - Roesey Keo Engineering. Details provided in Hornbuckle et al. 2016. Cost of the bucket with an external hydraulic pump and oil cooler was $4500US. Some tractors do not have the ability to run the external hydraulic control of the laser arm efficiently enough from on-board tractor hydraulic systems hence an external oil cooler and hydraulic pump was developed and used.

Assembling levelling bucket and Trimble laser with tractor

A Trimble laser levelling unit was sourced from Vietnam from Ideal Farming Corporation. Current pricing of a laser levelling unit with hydraulic controller is $7255US.

The Trimble laser unit was then integrated with the laser bucket and Russian 80 HP tractor and assembled and tested.

Undertake training (theoretical and Practical) on using laser levelling equipment

The laser land levelling training was conducted by Mr. Som Bunna (CARDI) on the process and benefit of laser land levelling. This involved a theoretical session followed by practical demonstrations and hands on learning on the CARDI paddy fields. A series of workshops and smaller training activities were then held between CARDI and MOWRAM and a joint manual and set of farmer information notes where developed for future use.

Demonstration and dissemination of laser land levelling to Government officials, private sector and farmers

Laser land leveling demonstrations were then conducted. These included demonstration in:

- Ta Keo and Kampong Thom Provinces,16 ha in 2013
- Pursat province, 10 ha in 2014
- Kampong Thom Province, 15 ha in 2015

At each of these campaigns local farmers and local authorities were invited to demonstration days where the project team demonstrated the laser levelling techniques and provided information on the benefits on laser land levelling. This included handouts on the benefits of land levelling (yield increase, water saving, weed control, reduce time and labour). Additionally, information on direct seeding and crop management was provided with most farmers switching to direct seeding after laser levelling had occurred.

Monitoring of the effects of laser levelling

At the sites in which laser levelling was undertaken in subsequent years during the project farmers were surveyed on the yield performance and basic experiences (weed management/ crop establishment) after laser levelling.

Establishing private sector laser levelling service providers

The project sought to develop a private sector laser levelling industry in Cambodia. The model involved jointly training private sector individuals in laser levelling and supporting private industry partners interested in offering laser land levelling services to undertake demonstration trials and then supporting them through a land subsidy to help them establish during the 1st season of

levelling. Material and training developed during the outscaling phase of the project was used to do this.

Further details on methodology are given in Hornbuckle et al. (2016).

RESULTS

Intensive on-farm research trials

These demonstration were used to compare laser-levelled fields with non-levelled fields and investigate impacts on yield, water use and weed growth. The treatments included both a laser-levelled field and a non-levelled field under the same management at each site and a neighbouring field. Water use was monitored by measuring water applied with a pump of 5.5 horsepower (20 m3/hour capacity). All water applied for irrigation, yields and weed biomass were monitored. Pre-levelled field topographies indicated that fields ranged from 10 cm to 30 cm variation in surface elevation. After fields were laser levelled, there was a 1–3 cm variation in surface elevation.

The field trial results indicated that weed biomass was approximately 50% lower (Figure 1), pumping-water requirements were lower and there was a 13% higher yield (Figure 1) in laser-levelled fields compared with non-levelled fields under the same management. The benefits of levelled fields on water use productivity are quite evident (Figure 2). Irrigation water applied to rice grown in laser-levelled fields was approximately 7,000 m3/ha, about 1,300 m3/ha less than non-levelled field (Figure 2). The field experiments show that there are significant benefits to water use productivity from the use of laser levelling to improve water management that, in turn, lead to improved water productivity. As increases in farm labour costs occur and farmers move to increase mechanisation, the benefits of laser-levelling technology will further increase, particularly in relation to direct sowing

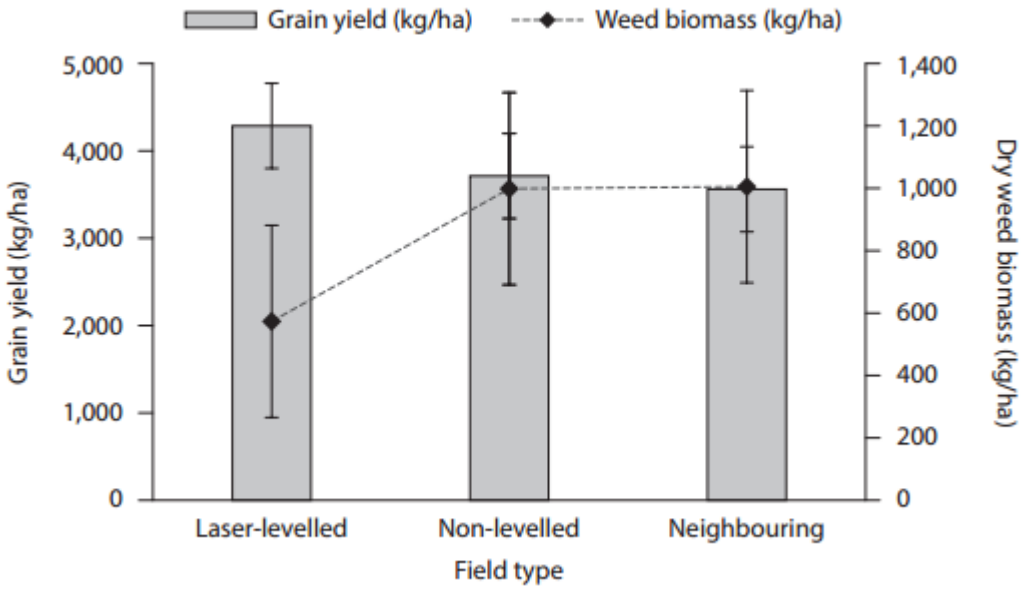

Figure 1 Grain yield and weed biomass across fields

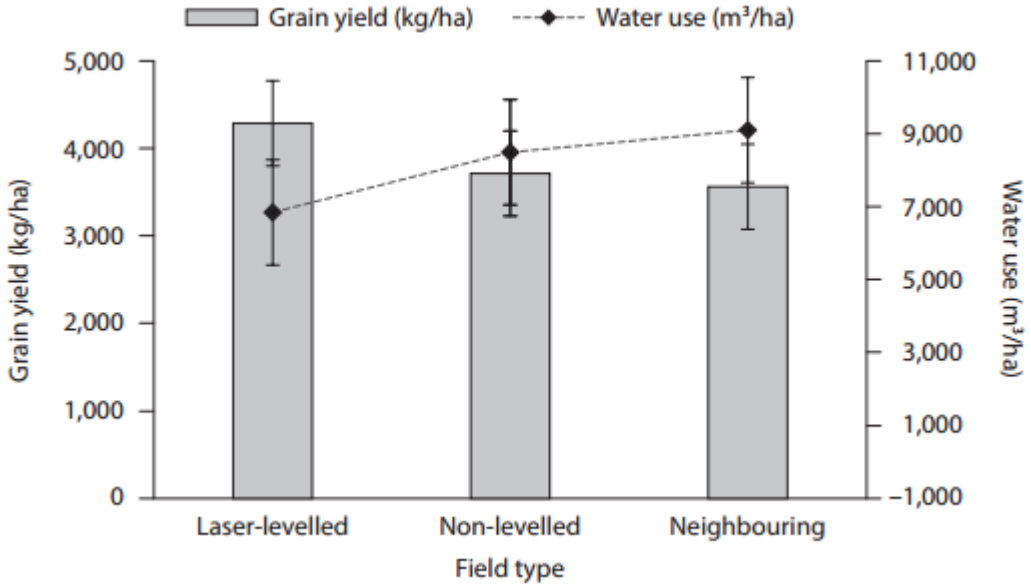

Figure 2 Grain yield and water use across fields

While the comparative studies have shown that land levelling and appropriate fertilizer usage has increased yields by more than 30%, other benefits have also occurred. Good land preparation and water management has reduced in-crop-weeding time from 21 to 5 labour-days/ha and reduced weed biomass by up to 40%. Levelling has allowed larger fields to be used and this has increased the farming area by 5-7%. Levelling has also increased the opportunity for direct seeding, which has reduced the labour requirement for crop establishment from 30 to 1 labour-days/ha. Water use efficiency has also been improved by using water from higher fields to wet up, to establish, and secure crops, in lower fields.

Outscaling laser levelling and district yield impacts

Yield responses to laser levelling where collected from three provinces in which laser levelling was undertaken in the project outscaling phase. These farmer fields had their field's laser levelled as part of MOWRAM rehabilitation activities and in subsequent years surveys on yield were collected. All farmers after laser levelling of the fields changed their management practice to direct seeding from transplanting, based on information provided to them at the demonstration and training days by the project. It can be seen from Figure 3 that in the Takeo Province there was on average a 16% increase in yield in the 1st dry season rice crop after laser levelling. This then increased to 21% in the second year after laser levelling.

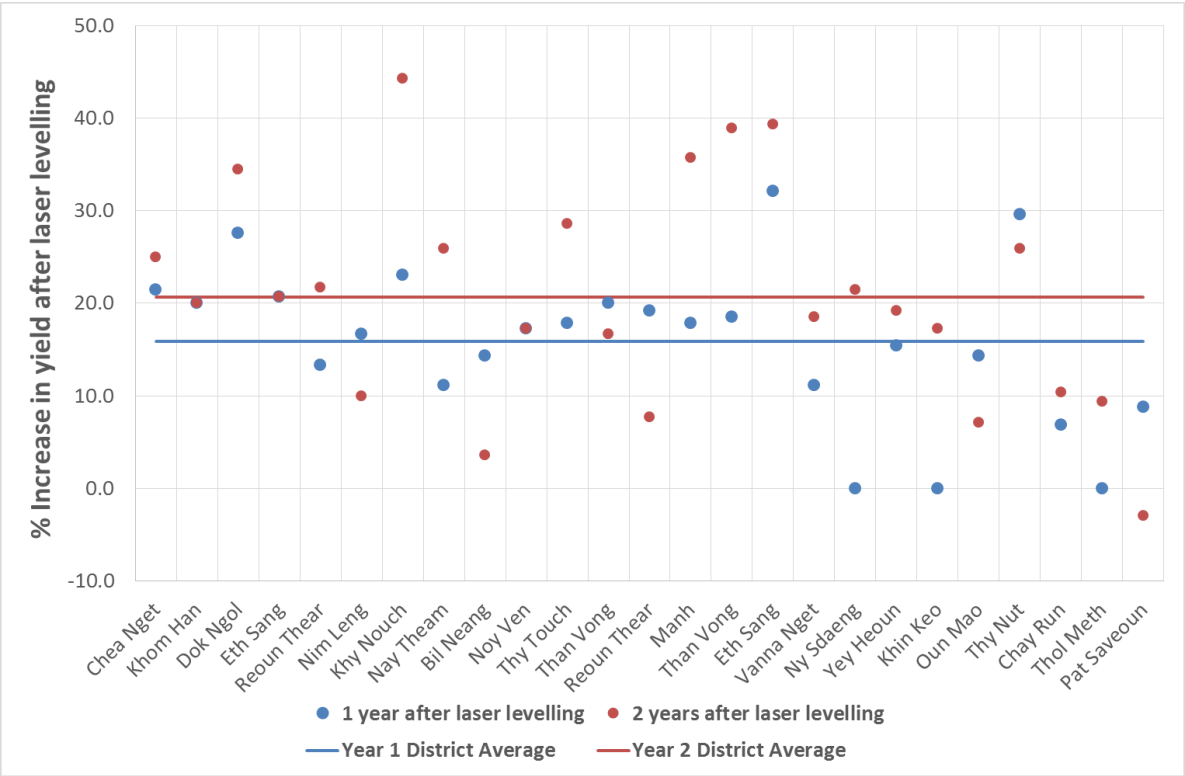

Figure 3 Change in yields following laser levelling across famers in the Tram Kok District, Takeo Province. Average yield increase was 16% one year after laser levelling and 21% 2 years after laser levelling

A very similar result was found in the farmers from the Kampong Thom Province (Figure 4) with an average yield increase of 15% after the 1st season, increasing to 20% in the second season after laser levelling.

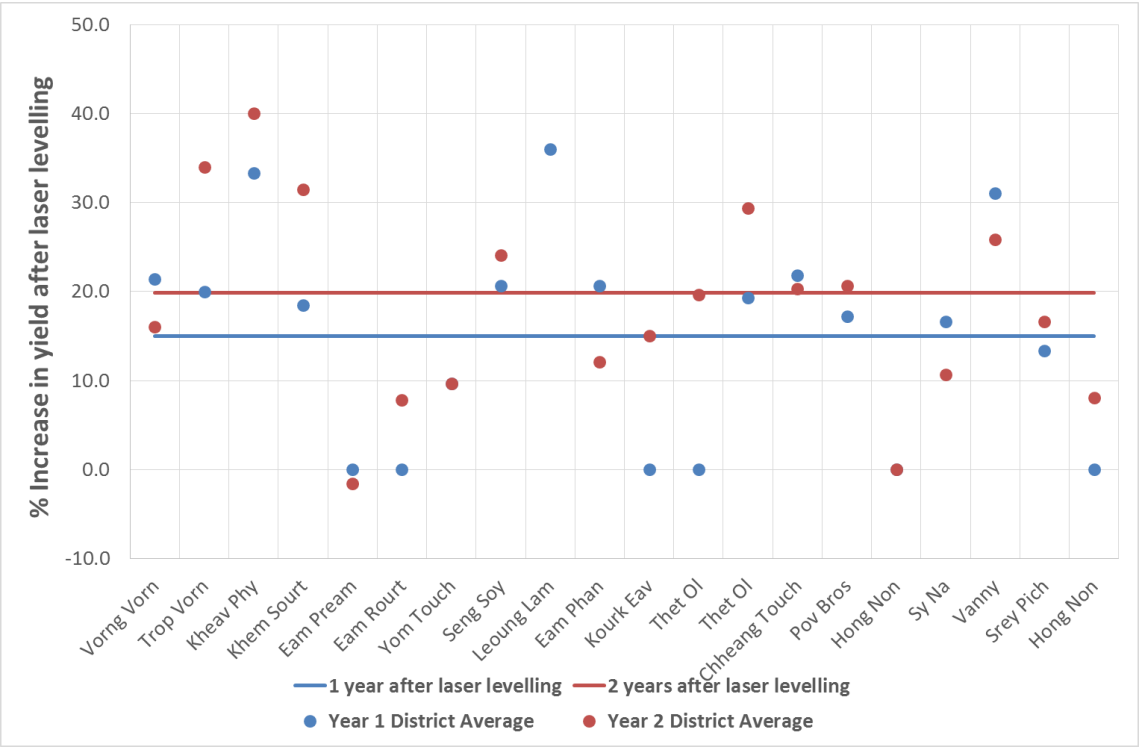

Figure 4 Change in yields following laser levelling across famers in the Kampong Svay District, Kampong Thom Province. Average yield increase was 15% one year after laser levelling and 20% 2 years after laser levelling

In both Provinces there were a few farmers who had little increase in yield, particularly in the 1st year which may have been due to a significant change in the management practices and time need to be able to adjust to these – i.e. moving from transplanting to direct seeding. From these follow up surveys, farmers indicated that they saw four main benefits from laser levelling. These were:

- Ease of water management
- Reduced labour by changing from transplanting to direct seeding
- Increased yields
- More effectiveness of applied fertilisers

<u>Establishing private sector laser levelling providers</u>

Workshops were undertaken in Phnom Penh in 2013 with the aim of developing a mechanism to support the establishment of private sector laser levelling service providers. The model focused on developing training and support to private industry by project partners to train industry staff on operation of laser levelling equipment and help with initial setup of small demonstration areas (Figure 5). Once demonstrations have been undertaken then support is provided as incentives to laser level further areas of land through a subsidy on the area of land levelled for the first 20 ha. One private sector operator who has undertaken the programme is Mr Reach Sorin in Battambang, province and is used here as a case study. In the late dry season of 2015, 6.5 ha of paddy fields were laser levelled by Mr Reach in the Battambang Province as field demonstrations in co-operation with CARDI. Mr Reach currently operates a contract harvesting and ploughing business and saw great potential for laser land levelling to fit into his current business model and has now purchased a laser bucket to continue to offer a laser levelling service with his current 95 hp tractor. Mr Reach see's a

logical fit to his current business activities. During 2016 Mr Reach was able to level 32 ha with his own equipment and staff and is looking to significantly increase this in 2017.

Figure 5 Field based training on laser levelling for private industry (left) and private industry laser levelling operations in Battambang, Cambodia (right)

Challenges faced have included developing a cost recovery model that suits private sector business, allows farmers invest in levelling and also operational issues related to weather and windows when laser land levelling can be undertaken.

Currently, costs are approximately $300-500/ha but are dependent upon initial field conditions and farmers seemed reluctant to pay on a per ha basis. Mr Sorin has now moved to an hourly rate which farmers feel more comfortable with and reflects the cost variability of different initial field conditions i.e. how much soil needs to be moved. Additionally, he is offering a payment plan whereby the farmer splits costs of laser levelling into an upfront component and then a further payment after harvest has taken place.

In order to develop some understanding of the economics of laser land levelling a simple analysis is presented in Figure 6 using the concept of a “Payback” period based on results collected on the farmer demonstration and experimental sites and the larger district yield surveys undertaken by TSC above. Both small scale experiments and larger district scale surveys of laser levelling indicate a likely increase in rice yields after laser levelling in the order of 20%. Paddy price was assumed to vary between $200US and $350US per tonne. Figure 6 show payback periods for an initial 3 t/ha crop before laser levelling assuming a 20% increase in yield after laser levelling. It can be seen that at these low yields and paddy price at $200/t, with initial land levelling costs at $400/ha payback periods are between 2-3.5 years. As paddy rice price increases than pay back periods are shortened considerably. At $350/t and an initial laser land levelling cost of $400/ha then payback periods are under 2.5 years.

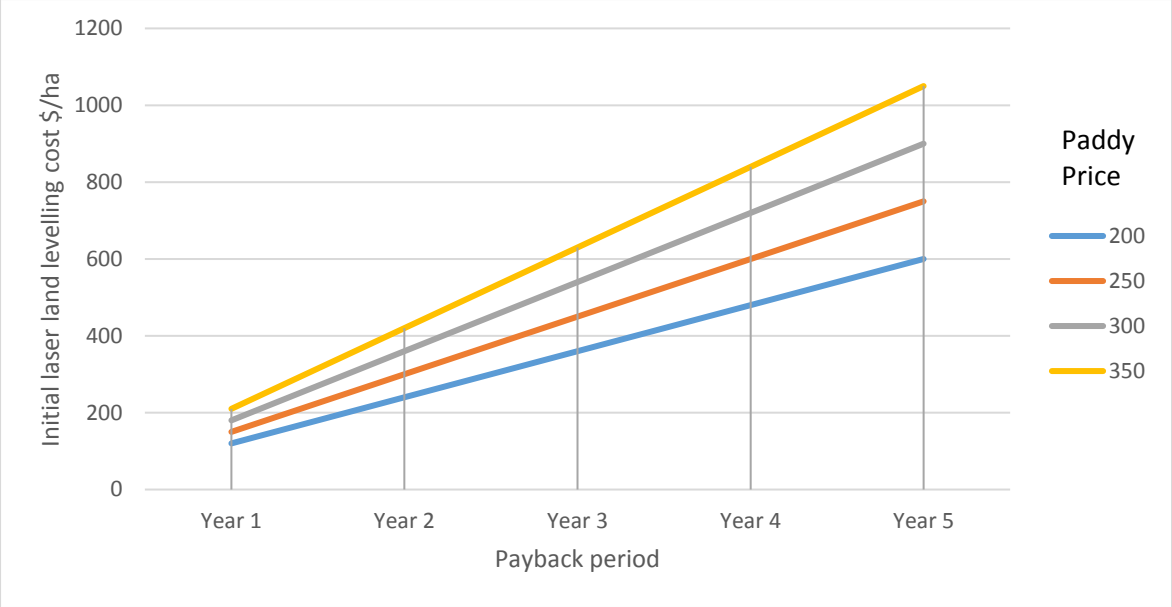

Figure 6 Payback period with initial starting yield of 3 t/ha and 20% increase in yield from laser levelling

It can be seen that using under most situations payback periods will be between 2-3 years for most farmers who implement laser levelling technology.

CONCLUSIONS

Improved water management is a key factor in increasing rice production in the Cambodia. Variability in the level of land within a field will have a major effect on crop management and crop yields. Uneven fields require more water to wet up the soil and land preparation and plant establishment is more difficult. Uneven water coverage often results in uneven crop stands, weed problems, uneven rice grain ripening and uneven rice grain yield. Land levelling, therefore, remains a technique that offers potential for significant impact on increasing water use efficiency, both directly and through the opportunities it provides for improved crop management.

In summary the project has been able to demonstrate the benefits of laser land levelling using both farm scale and district scale approaches. These have indicated a likely average increase in yield of approximately 20% on dry season rice yields. Additionally, weed control is dramatically increased and water management becomes more precise. However, broad-scale adoption is not wide spread yet as initial capital costs are high (approximately US$400-500/ha) and there is no wide scale established laser-levelling industry in Cambodia, which together constitute a major barrier to broad-scale adoption. However, successful private industry laser levelling providers have been established within this project and it is hoped this number will grow in time as the technique becomes more widespread and benefits seen by other farmers. In order to overcome this hurdle, policies that allow this technology to be implemented, such as farmer subsidies for laser levelling, would assist in further kick-starting the industry. Increased yields are not the only benefits anticipated. Water savings arising from less water applied to laser-levelled fields have the potential to be redirected into more irrigated rice area and its associated production outcomes.

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REFERENCES

ADB (2010). Key Indicators for Asia and the Pacific. Unpublished, Asian Development Bank, Mandaluyong City, Philippines

CRDI (2012). Cambodia Development Resource Institute. Annual Development Review 2011-12. Phnom Penh, Cambodia

Hornbuckle, J.W., Som, B., Touch, V., Seng, V., Oeurng, C., Prum, K., Collins, M., Quayle, W., Lim, V., Men Pagnchak., Charlesworth, P., Zandona, R., Smith, D., Hin, S., Sok, T., Num, V. & Pao, S. (2016) Improved irrigation water management to increase rice productivity in Cambodia, Australian Centre for International Agricultural research, Canberra. http://aciar.gov.au/publication/fr2016-20

MAFF (2011). Annual Development Report for 2010-2011 and Target for 2011- 2012. Ministry of Agriculture, Forestry and Fisheries (MAFF) (Phnom Penh).

Mainuddin, M. & M. Kirby (2009), “Spatial and temporal trends of water productivity in the lower Mekong River Basin”, Agricultural Water Management, 96, pp. 1567- 1578

MOWRAM (2009). Action Plan on the Development and Management of Water Resources and Meteorology for Contributing to the Implementation of the Rectangular Strategy - Phase II. Unpublished, Ministry of Water Resources and Meteorology (MOWRAM): Action Plan (2009-2013).

Rickman, J.F., (2002). Manual for laser land leveling, Rice-Wheat Consortium Technical Bulletin Series 5. New Delhi-110 012, India: Rice-Wheat Consortium for the Indo-Gangetic Plains. pp.24.

Wokker, W., Santos, P., Bansok, R. and Griffiths, K. (2011). Irrigation water productivity in Cambodian rice systems. Working Paper Series No. 51 (Phnom Penh: CDRI).