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Engendering Field Water Conservation by Crop Water Assessment Device (CWAD) Using Feedback and Social Nudges

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***Abstract* – As opportunities to enhance the irrigation base for raising food production in India are dwindling. Growing regions need more concerted efforts to increase the efficiency and productivity of the irrigation systems. Recent agricultural research is also focusing on modes to increase the water productivity of cropping systems. Understanding that eventual large-scale adoption of a new methodology is dependent on changes in farmer behavior, we have utilized the key principles of behavioral economics default option, goal setting, and feedback to develop a device to bring in an entirely new system for crop water application. Towards this a Crop Water Assessment Device (CWAD) is developed. Three aspects of different rice cultivation, using the CWAD for water saving, water use efficiency and water productivity were analyzed. CWAD placed at decision points provided feedback on water levels and nudged farmers into more mindful irrigation instead of flooding. The study found a 38 percent reduction in water use with the CWAD. Our main focus in the nudge program was to change the irrigation behavior of the participating farmers using instruments based nudge (CWAD). While comparing water productivity among conventional farmers and the CWAD farmers it is found that CWAD farmers use 832 liter of water less per kilogram of paddy production than conventional flooded condition. This has immense potential for increasing the cropped area and food security of the country.**

***Keywords* – Water Conservation, Social Nudges, AWD, CWAD, Water use efficiency, Water Productivity.**

I. Introduction

Agriculture accounts for 71 percent of global water abandonment, a quantity that we venture will turn down only slightly, to 65 percent by 2030. Water scarcity is connected both to on the rise and trading of food. India, for illustration, now has just partly in the water it will need in 2030, and cultivation will account for about half of the enlargement in water demand over the subsequent two decades. It will report for pertaining to half of all water used in China by 2030 and for concerning a third in Brazil and neither country will have a passable quantity of water for all its desires in 20 years.

Discovery behavior to use water more capably in agriculture is grave. Agricultural research has previously looked-for performance to design seeds and fertilizers that require less water, and improved drip irrigation technologies will remain farmers from over watering their fields. Numerous supplementary sectors can make available priceless solutions beneath the accurate monetary circumstances. An outsized industrialized corporation, for occurrence, could afford farming communities with pumps that it now sells to water utilities, augmentation its purchaser base whereas improving effectiveness in agriculture. IT solutions can facilitate the same as well. They are too pricey for continuation farmers, but water paucity may encourage consolidation and the materialization of larger farming groups that would need and could manage to pay for competence tools.

Even raising the water output of farms in rainy locales is a grave portion of the mystery. Maintaining rain-fed land and civilizing its yield are predominantly imperative, while to the extent that crop growing uses water from rain, it is redundant to extort water for irrigation. In India, this resource provides 17 percent of the total potential for cultivation to close the gap between demand and supply. The opportunities consist of a better fertilizer balance in the field, integrated pest management, and improved drainage systems.

In conclusion, fiscal institutions and investors can promote from labors to make better water productivity in behavior, competence and crop growing. Banks will need to make available funds for many water productivity reserves, more than ever when the civic sector cannot. The venture can be striking for lenders, but they will have to know where and how to use the outlay. In India, for occurrence, some drip irrigation projects could help farmers trim down the cost of certain inputs (such as fertilizer) by up to 50 percent, depending upon the produce. Investors could capture a share of this value either as lenders or as impartiality holders in companies active in the drip irrigation value chain. China needs about $1.8 billion a year in investment to condense outflow in community water systems. With a 22 percent rate of revisiting, these reserves could be an eye-catching solution for the community utilities and their lenders the same.

II. Methodology

Understanding that eventual large-scale adoption of a new methodology is dependent on changes in farmer behavior, we have utilized the key principles of behavioral economics default option, goal setting, and feedback to develop a device to bring in an entirely new system for crop water application. An appropriate technology based device, Crop Water Assessment Device (CWAD), has been developed for paddy field moisture control. The CWAD measures and provides feedback by assessing and visually indicating to the farmer the extent of soil moisture available in the root zone. The device has two default water level indications at 5 cm and 15 cm height, which correspond to the minimum and maximum desirable moisture levels, respectively.

Paddy cultivated villages (10 numbers) of three districts in three different agro climatic zones of Tamil Nadu were selected purposively and focused group discussions were conducted with the farmers. As per the village had cultivated paddy for three seasons under waterlogged conditions; however, owing to severe drought conditions, paddy could not be cultivated for three seasons recently, since the paddy crop dried in the grain filling stage without sufficient water. In each village, fields of four SRI (System of Rice Intensification) followed farmers were randomly chosen for the CWAD trial and one conventional farmer from the same village was chosen as a control. The CWAD protocol followed in this study included transplantation of young seedlings (14–21 days) within a square area of 25cm, mostly as single seedlings per hill, with alternate wet and dry irrigation, and mechanical weeding 1-3 times before canopy closure using a rotary weeder.

These practices were for the most part followed by the farmers in the experimental fields, with feasible dissimilarity in irrigation levels. Some farmers frequently kept their field water at dispersion level, some irrigated their field behind considering hairline cracks in the soil surface, and a number of others maintained a skinny film of water on the ground. In any case, the water management followed was considerably different from the conventional practice of continuous flooding.

This paper compares the performance of the CWAD trial fields and conventional rice fields in 10 villages of 50 farmers of Tamil Nadu. In this study, CWAD has been promoted over the study period by farmers (i.e., self-help groups) with support from the Centre of Excellence in Change (CEC). It was an effort by the program to understand the impact of the new method on farmers' productivity and the quantum of water savings. The above practice is a water-saving technology that farmers can apply to reduce their irrigation water consumption in rice fields without decreasing its yield.

III. Farmer's Social Pressure on Irrigated Cultivation

Recent studies have found that "peer comparison" interventions, providing individuals with scientific information about the latest techniques to others, can change the behavior of others after full realization of the benefits. However, in these cases, demonstrations conducted in the individual's field may change the water conservation behavior to others. So unless these interventions also cause the individual to feel more compelled to share this information, or if such interventions cause people to talk about it with their neighbors. It is clear from social pressure concerns drive such effects like our alternate wetting and drying.

IV. Correcting or Manipulating Historic Beliefs

Few research evidences suggest that farmers exert more effort due to social pressure and work hard because they want to be as a peer by following innovative low-cost techniques. The pressure is greater more when the conventional farmer needs to be convinced about the new technique. Traditionally the paddy farmers feel that the rice is an aquatic plant requires continuous irrigations, it needs to be sensitized or manipulating the farmer's historic belief through social nudge practices. This study attempted a water conservation through alternate wetting and drying method for irrigated agriculture from the use of the crop water assessment device (CWAD) instrument.

V. Changing Expectations of Farmer's Social Desirability Through CWAD

The CWAD is assembled by inserting a flag into the disc and then combining it into a float. This float assembly is then placed into a clear perforated cylinder, thus completing the device assembly. The CWAD is placed vertically into the soil at a depth of 15 cm. The bottom portion of the holocylindrical body is open and the cylinder is pushed into the transplanted rice field up to 15 cm in depth and the field soil inside the holocylinder is removed manually.

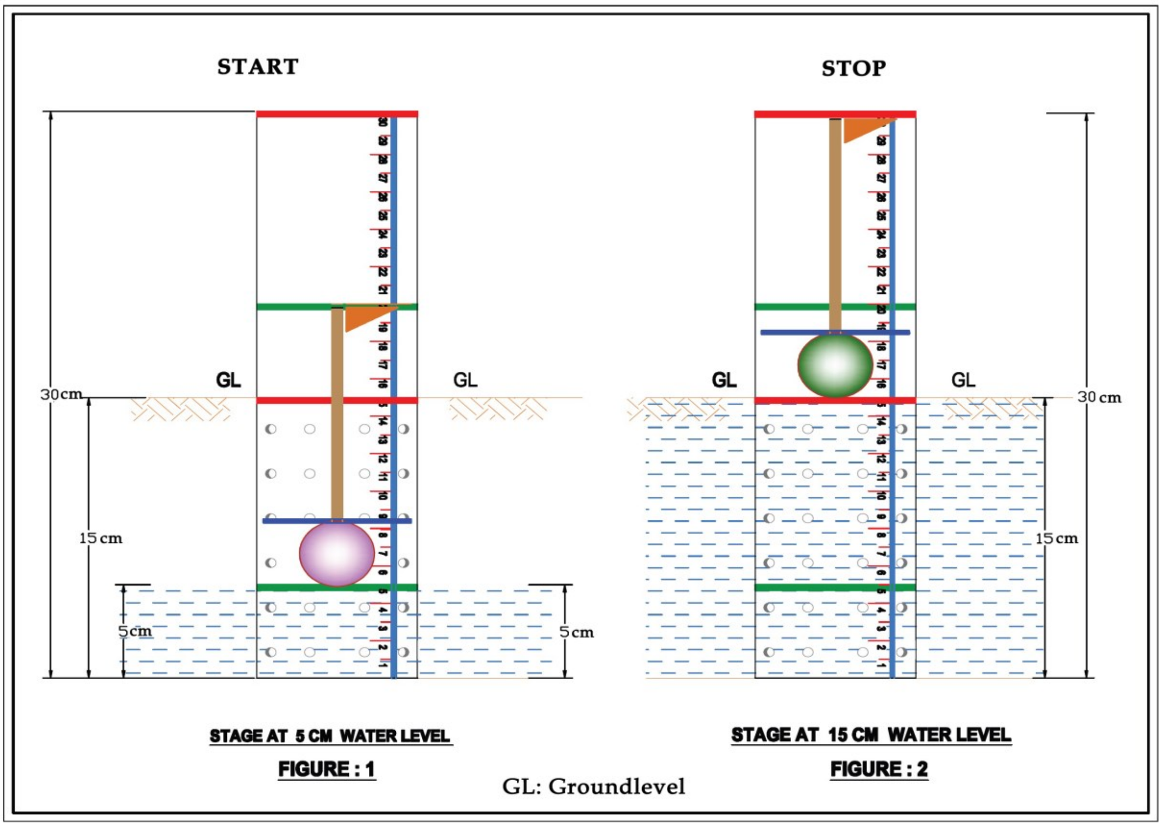

Fig. 1. Crop Water Assessment Device (CWAD)

The immersion into the soil matches the fibrous root zone of most food crops like rice and has the ability to assess water available in the root zone. The device is strategically placed near the crop at the randomly selected place.

As water is applied to the crop, it percolates into the device from the surrounding saturated soil and rises to the level of water in the root zone. As the water rises in the cylinder, the float and flag assembly also float in the water column and rises vertically. The flag touching the 30-cm red ring is an indication that the root zone is completely saturated (even though the soil surface may appear dry) and indicates for shutting off of the water supply. This is crucial in preventing excess application of water, prevents wastage of precious water and electricity, and prevents reduce crop yields.

With time the crop use and evapotranspiration losses will reduce the water available in the root zone. Correspondingly, the water level in the cylinder will also fall; the float assembly will also drop. As the float drops to 5 cm from the base, which is the minimum level of water designed in the root zone, the flag again touches the red ring, indicating the farmer needs to restart the application of water. As it is a clear cylinder with a flag device, the flags, the measurements, and the corresponding indication levels are visible to the user from afar. Second, to convince farmers to change their water management behavior, he needs to be able to physically see the water level in the root zone. The transparent device aided by markings makes it possible for the farmer to read the water level measurement.

The two sets of farmers whose practices and consequences were deliberate were thus reasonably analogous. The latter set was regarded as controlling. Thus, there were full sets of data for 10 conventional and 40 CWAD farmers. The data from the CWAD farmer treatment and conventional paddy production were collected over the entire spell. The number of pumping hours and the motor efficiency used in paddy cultivation of CWAD and control farmers was selected as a proxy variable to understand the difference in water use, as followed by Ravindra etal.,2010.

VI. Results and Discussions

In the study area, the CWAD farmers followed discontinuous irrigation with alternate wetting and drying cycle as opposed to nonstop flooding of fields (≥10 cm standing water) by conventional paddy farmers. CWAD practice led to a significant dwindling of irrigation numbers, pumping hours, and on the whole water usage. The mean water measurement observations in CWAD fields at 10 different locations in Tamil Nadu (Fig. 2) Clearly demonstrated that CWAD paddy required only 874 mm of water as against 1206 mm (mean of locations) for conventional paddy cultivation. The 38 percent water savings were observed due to the adoption of CWAD.

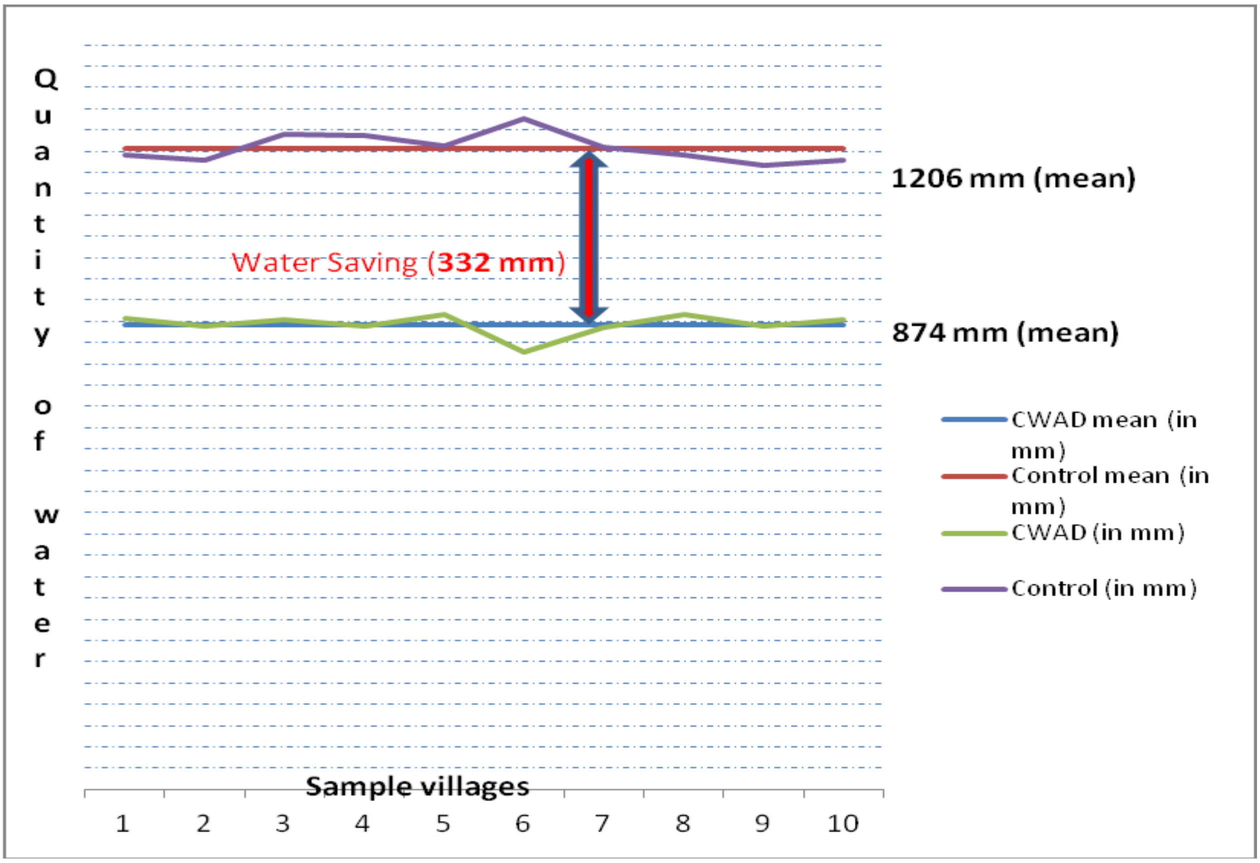

Fig. 2. Water Used and Saving in Sample Fields

Table: 1 Water Requirement Studies in Alternate Wetting and Drying Irrigation by CWAD for Paddy Cultivation

Sl. No.	Village	Water Used in mm		Productive Tillers/Hill		Productive Tillers/m^2		Grain Yield (Kg/ha		Water Use Efficiency (Kg/ha/mm)		Water Productivity (lit/kg)	
		CWAD	Control	CWAD	Control	CWAD	Control	CWAD	Control	CWAD	Control	CWAD	Control
1	Kizhmaruvathur	886	1192	29	24	493	420	6409	5460	7.23	4.58	1382	2183
2	Mazhuvankaranai	872	1184	30	26	510	455	6630	5915	7.60	5.00	1315	2002
3	Kesavarayanpettai	883	1231	28	25	476	438	6188	5688	7.01	4.62	1427	2164
4	Sirunagar	870	1229	29	24	493	420	6409	5460	7.37	4.44	1357	2251
5	Thirumazhisai	894	1209	30	26	510	455	6630	5915	7.42	4.89	1348	2044
6	Aranvayal	822	1260	31	25	527	438	6851	5688	8.33	4.51	1200	2215
7	Nemili	868	1208	29	24	493	420	6409	5460	7.38	4.52	1354	2212
8	Vellavedu	893	1192	29	24	493	420	6409	5460	7.18	4.58	1393	2183
9	Vandayar irrupu	871	1174	33	23	561	403	7293	5233	8.37	4.46	1194	2244
10	Kambarnatham	883	1183	31	25	527	438	6851	5688	7.76	4.81	1289	2080
	Average	**874**	**1206**	**30**	**25**	**508**	**431**	**6608**	**5597**	**7.57**	**4.64**	**1326**	**2158**

The data (Table 1) clearly indicated that water requirement was lesser under CWAD management when compared with the conventional method as reported by Barah (2009), Kasam Amir etal., (2011). CWAD registered a higher grain yield and water use efficiency (6608 kg/ha and 7.87 kg/ha/mm, respectively) when compared with conventional systems (5597 kg/ha and 4.64 kg/ha/mm, respectively). It is evident from the above observations that in changing the decision behavior of farmers through the adoption of the instrument based nudge practice, there is a significant quantum of saving in irrigation water, in addition to higher water productivity and the higher grain yield. Additionally, the alternate wetting and drying method lead to an aerobic situation for paddy cultivation. The development of hairline cracks at the ground level due to the alternate wetting and drying (AWD) enhances the availability of soil phosphorus, maximizes the number of roots and its surface area, and enables higher absorption of nutrients from the rhizosphere. Thus, there is more assimilation of food at the source and efficient translocation of photosyntates to the sink portion of the plant, leading to increased yield as observed by Turner, Haygarth 2001 and Zhao etal (2009).

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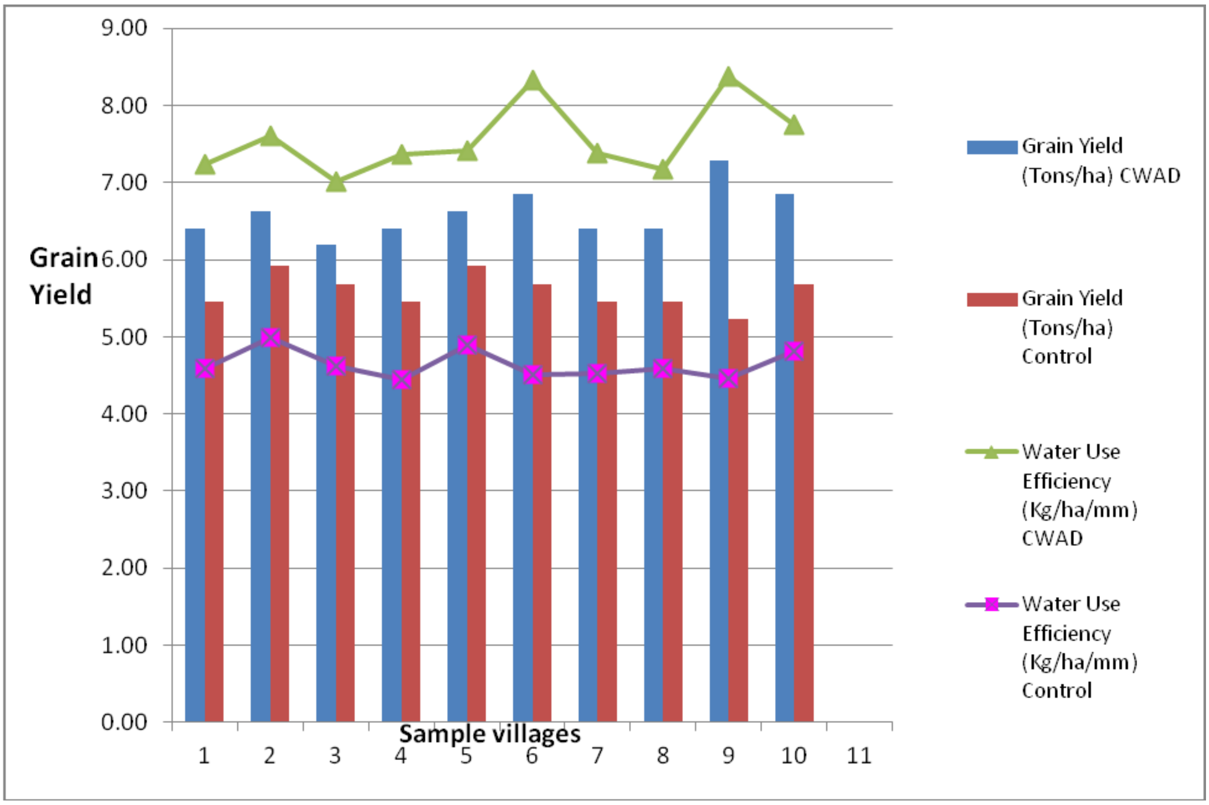

Fig. 3. Grain Yield vs Water Use Efficiency

The higher yield contributes to a portion of income increase to the farmer and reduces energy usage in terms of electricity and water. Also, these nudge practices protect the crop under minimum water availability conditions. Instead of an average irrigation of 13 times per crop in the field, we need to only provide irrigation nine times. The study found a 38 per cent reduction in water use with CWAD, 34-53 per cent increase in the water use efficiency and 47-66 per cent increase in irrigation water use efficiency when compared among the conventional flooding. The saved water used for increasing area under cropping.

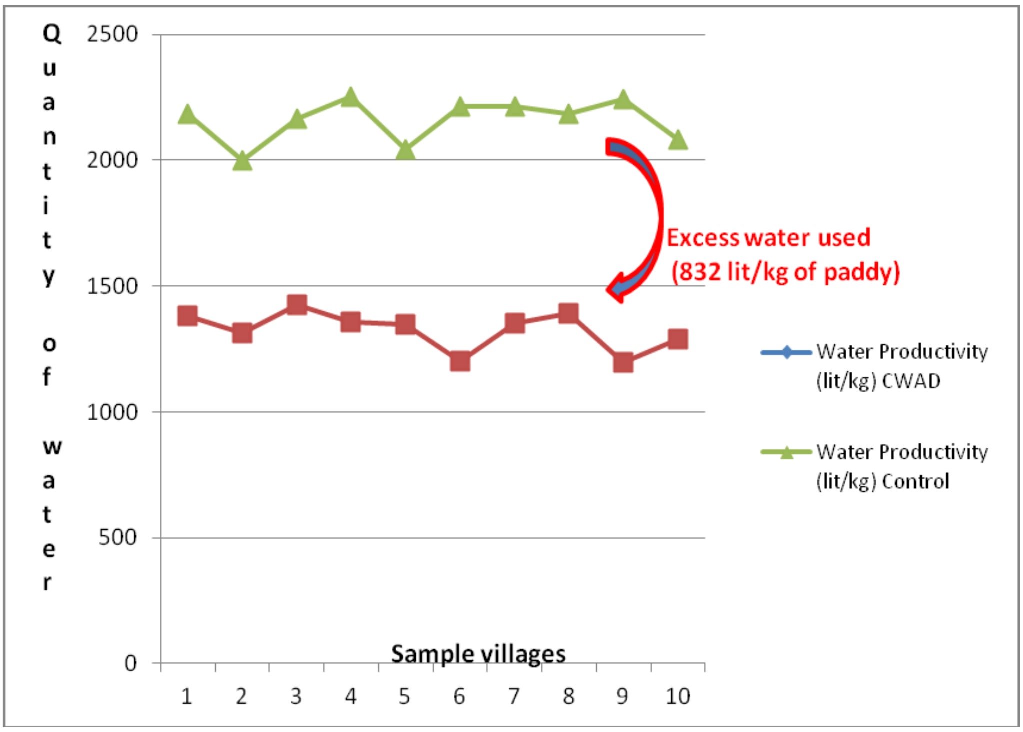

Fig. 4. Water Productivity (lit/kg) Comparison of CWAD vs Control

Our main focus in the nudge program was to change the behavior of irrigation of the participating trial farmers using instrumentation nudge (CWAD) with lesser water productivity. When comparing water productivity among conventional farmers (2158 liter/kg) and CWAD farmers (1326 liter/kg) respectively, an excess of 832 liter of water had been used per kilogram of paddy production in the conventional flooded condition of as usual business scenario.

Nudging, a performance that influences people towards advantageous performance as found in urban context by Amishi and Kanaka (2017), can be used as an impending means of transportation for agriculture conservatory. This nudging concept is different from incentivizing. Farmers were shown to increase their productivity through the adoption of nudge concept in a USAID Agricultural Innovation Project in Pakistan. (Amishi & Kanaka, 2017)

Farmers, particularly during times of stress or during busy times of the year, often fail to plan and take proper decisions and subsequently fail to match their intentions with actions on the ground. This is relevant, considering that many good management practices and sustainable approaches to farming requires a high level of systemization in adopting agricultural management.

Farmers spend much time responding to challenges arising from dry spells; this competes with the cognitive space and the effort required to plan and executes good management practices and it becomes an additional burden. Much of the research emerging from the field of behavioral economics points to the fact that people may systematically make mistakes and may fail to adhere to processes and techniques that are "rationally" superior.

The significance of utilizing nudging as an innovative and gratis course of action instrument in impending areas can help hoist agricultural efficiency. With the energetic contribution of farmers, techniques such as nudging could be successfully used for sustainable enlarging of the agricultural division. Nudging is a practice that influences people towards enviable behavior.

This study has found that peer comparison interventions through AWD experiments conducted with individuals is providing information to others can change their behavior.

VII. Scope of The Findings

The practicing farmers realized that the use of the CWAD could broaden their knowledge in saving water and consequently lead to a substantial expansion of irrigated area.

There is a marginal increase in yield upon the adoption of the AWD due to higher tillering and more filled grains as in assessment with the findings of Vibhu Nayar etal (2012) and Ravichandran etal (2015). There is ample scope for upscaling, this prudent and easing adaptable technique among the rice growing region of the entire Tamil Nadu state as well as the nation.

At a national level, 43.27 m.ha of rice was grown (average of 7 years, 2009-2016) by consuming 519.3 BCM (billion cubic meter) of water. Adoption of the AWD practice in the even 50% of the rice cultivated areas could save 85.6 BCM (the saving of 38%) of fresh water, which in turn could bring an additional area of 7.1 m.ha of the irrigated rice crop, to make certain the food safety of the country.

Similarly, in Tamil Nadu state, 1.82 m.ha of rice is grown annually by consuming around 21.84 BCM of irrigation water (average of 7 years, 2009-2016) and adoption of this water-saving technique in even 50% of paddy grown area could save 3.6 BCM of fresh water annually.

VIII. Green House Gas Emission

Alternate wetting and drying practices a transit system for the conventional flooded rice ecosystem, limiting the total flooding period, during which the rice crop methane emission is reduced by an estimated 5.97 t CO_2 equivalent per year (IAMWARM 2015), showing a positive influence on environmental protection, as observed by Joel et.al (2013).

Adoption of this AWD practice in even 50 percent of rice-growing areas could reduce methane emission to around 129.2 mt and 5.17 mt of CO_2 equivalent of the national and state levels, respectively.

IX. Conclusion

This result has asserted that, the adoption of CWAD is more ecologically sustainable rice production system owing to higher water productivity, higher yield, efficient water use and lesser carbon footprint. Even though SRI has some practical problems for field adoption, this system of rice cultivation needs to be explored more due to increased water savings. Enhanced water management in rice production systems has the prospective to extensively diminish agricultural greenhouse gas emissions, while tumbling freshwater use, escalating the productivity of rice cultivation and maintaining the profitability of one of humanity's staple crops. Though, a large amount occupation leftover to be done to reliably calculate approximately these remunerations and to give confidence implementation of these practices at the indispensable scale. Nevertheless, enhanced water management in rice cultivation systems is expected to be an imperative item on the list of options for a sustainable food potential. Extension programs that afford broad irrigation information and unambiguous information concerning the CWAD can give confidence advance implementation of this irrigation practice.

Acknowledgment

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