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Rooftop Rain Water Harvesting Technology and Women Time Allocation in District Bagh and Battagram Pakistan

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1. INTRODUCTION

Water is essential requirement of life and accessibility to safe drinking water is the fundamental right of every human being [IUCN (2004)]. It is not only an essential component of primary health care but it also plays a vital role in livelihood security and national economic development [Mustafa, *et al.* (2009)]. With the passage of time water is becoming a scarce resource all over the world. It is scarcer in low income countries, where majority of the poor resides in the rural areas, results in water allocation problems [Xinshen, *et al.* (2005)]. This scarcity is due to number factors like, agricultural intensification, industrialisation, and increasing population pressure. It is the dire need of time to formulate some practical strategies to address the issues of water crisis. In this regard a number of approaches including Rain Water Harvesting (RWH) are being practiced.

RWH is one useful approach to conserve, store and utilise rain water from different catchment areas. In addition to sustainable supply of water for domestic consumption, this technology will ease out the pressure from existing water sources. RWH is an old but useful approach to channel and use the rainwater in productive manners [Li, *et al.* (2000) and UNEP (2009)]. It has special importance for Pakistan as the country is confronting acute water shortage. World Bank (2005) has already declared Pakistan as water stressed country in South Asia. Supplying water in hilly areas is time consuming, hazardous, and costly business with numerous risks involved with it [Baguma, *et al.* (2010)]. World Bank (2005) also recognised that RWH is the most suitable and viable approach for hilly areas of Pakistan.

Given the increasing risk of water crisis in Pakistan, some agencies have taken the initiatives to ensure the sustainable supply of water in rural areas. In this regard Earthquake Rehabilitation and Reconstruction Authority (ERRA) has initiated a project of Rooftop Rain Water Harvesting (RRWH) technology in seismically sensitive areas of Pakistan. This project has been scaled up from its pilot to full fledge implementation phase which includes almost all earthquake affected districts of KPK and AJK Pakistan.

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Governments of Pakistan along with a number of donor agencies are supporting this project right from its conception. The project has targeted rural communities of earthquake affected areas, who are most vulnerable with respect to water availability. Present study is the evaluation of pilot phase of the project and it analyses the technology with special reference to women time allocation in those communities.

The rationale of the study is that, before this technology woman were fetching water far from their dwelling units which required large amount of time to visit the source of water every day. After the implementation of the technology it is assumed that women time of water fetching has significantly reduced. Based on this presumption that RRWH technology has altered the time allocation of women in respective communities, present study aims to investigate the overall impact of technology on women time allocation.

2. RRWH TECHNOLOGY AND WOMEN TIME ALLOCATION

Since this is the first ever initiative when RRWH technology is being formally implemented at large scale, there is paucity of literature on the subject from Pakistan. Authors could not find any study in Pakistan on RRWH technology and specifically its impact on time allocation. However, some studies on RRWH technology with special reference to time allocation were found from abroad but most of the authors studied the phenomena theoretically and have not tested the impact empirically. Study has cited some of the relevant research in following paragraphs.

Lehmann and Tsukada (2009) and examined rainwater harvesting with reference to health and time allocation. They conclude that this technology reduces cost incurred on health as well as time allocation for curing sick people, which could be used for profitable activities. Similarly, young children (both male and female) can go to school who are otherwise busy in fetching water. Furthermore, this system improves the sanitation and hygiene facilities to rural population by providing them water at home on sustainable basis.

Baguma, *et al.* (2010) studied rainwater harvesting with reference to human health and time allocation. Using the data and empirical evidences they concluded that this technology reduces cost incurred on health as well as time allocation for curing sick people, which could be used for profitable activities. They have indirectly reckoned the saving of time. Study also reported that, due to this technology young children (both male and female) have the time which they were spending to collect water before this technology. Now they can go to school who are otherwise busy in fetching water. Moreover, this system improves the sanitation and hygiene facilities to rural population by providing them water at home on sustainable basis. Study also argued that this technology has reduces the associated risks.

In Kenya, Elizabeth, *et al.* (2006) has conducted a research on water, women and social organisations. They have conducted a survey of some villages to investigate water-women nexus. Findings of the study exposed that, safe and easily accessible water has brought a range of benefits to those households, especially through activities where women have special responsibilities. Study reported that, households with improved water access have saved time, improved health, cleaner clothes, and increased production of tea seedlings, milk and vegetables, with the net result of significant increases in income controlled by women.

3. THEORETICAL CONSIDERATIONS AND ECONOMETRIC SPECIFICATION

This section briefly describes the channels through which the Rooftop Rain Water Harvesting (RRWH) technology and other control variables affect the women time allocation. Theoretically speaking, the RRWH technology is expected to have positive effect on women time allocation in terms of reducing their time which they are spending on water fetching. The RRWH technology has huge potential in terms of water supply and it facilitates women by providing them required amount of water which is otherwise brought from distanced water sources. Consequently, this facility saves their time which can be used in other productive and healthy activities.

Hence, one may expect positive impact of the RRWH technology on time allocation in rural and hilly areas. This variable of 'RRWH' is quantified by using a dummy variable where "1" represents the household possessing this technology (also called the "treated group") and "0" represents the household where this technology is not provided (also named as "control group"). On the other hand, the women time allocation is quantified as the 'TWT' total work time which they allocate in different activities time. The control variables used in the women time allocation model include Region, age of the women (Age), household income (HHInc), and education of the woman (Edu), distance from water sources (DWS), and social activities time (SAT).

The variable "region" is quantified using '1' for Bagh and '0' for Battagram. This variable is incorporated in order to investigate whether there is any impact of regional differences. "Age" denotes the age of water fetching woman. The expected sign of its coefficient is positive, because with the increase in age, women allocation of time is expected to increase. Because the body and the resistance weaken as the woman enters to older age group. Subsequently, a positive sign of the coefficient may also be expected.

Education, taken as the years of schooling of the water fetching woman, is expected to improve the women time allocation for the reason that the educated women are comparatively better aware of the productive allocation of time. Therefore, its expected sign is positive. DWS measures the distance of water source from dwelling unit in kilometers and its probable sign is negative, HHInc is the income of a household which may affect time allocation negatively because women time allocation may reduced due to increased purchasing power for goods and services from market. SAT is the social activities time which women allocate in their daily routine to interact with their friend, relatives and neighbours. Expected sign of its coefficient is positive. In the light of above discussion, the following econometric specification can be given:

$$TWT = \alpha_0 + \alpha_1 RRWH + \alpha_2 Region + \alpha_3 Ages + \alpha_4 HHInc + \alpha_5 SAT + \alpha_6 Edu + \alpha_7 DWS + \varepsilon \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

In order to estimate the above equation Ordinary Least Square methodology was used.

4. METHODOLOGICAL ISSUES

4.1. Overview of the Study Area

Study area includes two villages; one from district Battagram and, other from Bagh where RRWH project has been initiated. Battagram is a district of Hazara division

in Khyber Pakhtunkhwa province in Pakistan. Total land area of the district is 1301 square kilometers and the estimated population in 2004-05 was 361,000 [Battagram (2007)]. This district is located at 90 km from Abbottabad and 240 km from the capital of Pakistan Islamabad. Three main languages; Pashto, Hindko and Gojri are also spoken in the district. English and Urdu are also spoken and understood in offices. Battagram obtained the status of district in July 1993 when it was upgraded from a Tehsil and separated from Mansehra district [Battagram (2007)]. Before Battagram obtained the status of district, it was a Tehsil of the Mansehra district.

RRWH technology has been executed in Saroona, a village of Allai which is one of the two Tehsils, or subdivisions, of Battagram district. The geography of Allai valley is such that it is bounded by Kohistan on the north and east, by the Kaghan valley, Nandhiarh and Deshi of Deshiwals on the south, and by the Indus river on the west. Valley has been ruled by Khans (tribal rulers) until 1949, than it became the part of Pakistan [Battagram (2007)]. The residents of Allai valley were badly affected by the massive Earthquake on October 8, 2005 which destroyed the 'cable way'; a way to allow residents to cross the Indus River. Pilot phase of RRWH system was implemented in Saroona which is one village of union council of Allai. The total no of households of Saroona village are 330 [Battagram (2007)]. The total population of the village is 5000, whereas the average household size is 8. In pilot phase the facility of RRWH was provided to 50 households.

Bagh is one among the eight districts of Azad Jammu and Kashmir, Pakistan. Total territory of the district is 1,368 square kilometers [Bagh (2007)]. Bagh district has three sub-divisions, namely Dhirkot, Bagh and Haveli. It is said that name of the city is from a *Bagh* (garden) which was set up by the landowner of the area, which is now forest department. As a result, the area that is now the district headquarters was named "Bagh". This city was badly affected by the Earthquake on October 8, 2005 which destroyed the overall infrastructure of the district.

Survey of present study has been carried out from, Chitra Topi, which is the project site of RRWH. It is a village of union council Topi in district Bagh. This village is situated in the North East of Bagh city at an altitude of 7000 feet above from sea level and on a distance of 18 KM main city of Bagh. Topography of most of the Bagh city is based on hilly terrain. Number of the households in this village are 274. Total population of the village is 1918 in which males are 940 and females are 978. Overall literacy rate of the village is above 80 percent [Bagh (2007)]. The main clans of the Chitra Topi are Suddhen, Mughal, Qureshi. Suddhen is the most influential clan that take the lead and dominate in taking decisions at the local level.

4.2. Survey Methodology

To collect the data survey was carried out through personal interviews of respondents in the selected villages of both districts (Bagh and Battagram). This survey was based on pre-tested questionnaire which was followed to construct a sound and well-developed questionnaire. Population of the present study is based on two groups; the one provided with RRWH systems is called the "treated group", while the other using the traditional water supply sources within the same localities is entitled the "control group". The purpose behind this sampling pattern is to investigate comparative impact analysis of RRWH system.

In order to conduct the analysis, the study has taken the entire population of treated group. Because treated group was of 50 household in each village. Sample from control group of population was picked for analysis using Random Sampling technique. The methodology is selected for the reason that all samples of the same size have an equal chance of being selected from the population. Secondly the population in control group was homogenous with respect to water supply. Lastly, the approach was suitable provided the resource limitation, location and facilitation. The optimum sample is the one which maximises precision per unit given the cost, and by this criterion, Random Sampling is often superior over other methods.

5. RESULTS AND DISCUSSIONS

5.1. Descriptive Analysis

In descriptive analysis some of the important variables regarding water fetching women are presented. These variables includes; their Ages, Education, Social Activities Time, Sleeping Time, and Distance from Water Source, Per Day Time for Water Fetching, Persons Involved in Water Fetching, Daily Saved Time due to RRWH and its spending are included. In addition to overall sample results, statistics of the both regions are also presented separately (Table 5.1a). These summary statistics are clearly indicating the variations in sample across the villages. Moreover, these findings are contributing yielding a support to interpretation and understanding of econometric results.

Table 5.1(a)

Average of Women Ages, Education, Distance from Water Source (Km), Social Activities Time (Hrs), and Sleeping Time (Hrs)

Regions	Women Ages (Years)	Women Education (Years)	Distance from Water Source (kms)	Social Activities Time (hrs)	Sleeping Time (hrs)
Bagh	34	7	0.6	0.7	7
Battagram	33	0	1	0.5	7
Overall	33.5	3.5	0.8	0.6	7

Table 5.1 (a) shows that average age of water fetching women is 33 years in the overall sample, as well as at village level. Moreover, 12 years as minimum and 65 years as maximum age were reported across the sample. This information shows that on average water fetching women in both regions are young, which is understandable because it is a tedious job and it is difficult for old women to perform it. On the other hand it is the most potential age group which has comparatively higher opportunity cost of time. The water fetching time of women could be resourcefully utilised by adopting this alternative technology for water supply.

Women Education is very crucial variable of the study, because it affects the overall socio economic conditions of women, especially in decision making regarding employment, time allocation in domestic activities, maternal health, sanitation and

hygiene, and their medical checkups etc. The difference of education and its impacts are highlighted by the present study, because women education is totally different across the two regions (Table 5.1 a). Average years of schooling for women in Bagh are 7, whereas in Battagram there were no educated women. Furthermore, in Bagh maximum years of schooling was 16 years but in case of Battagram there was only one women which had 7 years of schooling, and it was the highest in that area.

Distance from water source is the average distance women have to walk while carrying the water. This variable has special importance with reference to women health and their time allocation. Survey of present study revealed that average distance from water source is 0.6 kilometer in Bagh while it was one kilometer in Battagram. This means that on average women have to walk more in Battagram, so they may be more vulnerable to water fetching hazards. Minimum distance reported in Bagh is 0.1 kilometer and maximum is 2 whereas, in Battagram it is 0.2, and 3 kilometers, respectively.

In rural areas, women often interact with their neighbours, relatives and close friends during the usual routine, which come under their social activities time. So, study has investigated their social activities time in order to analyse its pattern and impact on women comfort in both communities. Overall per day average time allocation for social activities is around one hour, but among both villages, it is higher in Bagh and lesser in Battagram. Because women in Battagram region are not allowed to go out of their homes. The minimum per day average time allocation for social activities is zero and maximum is 3 hours for both communities (Table 5.1 a). This is the social capital of rural women which help them in easing out the stress and managing daily life problems.

Sleeping time of women is very crucial indicator with reference to women wellbeing. On average reported sleeping time of women was 7 hours in both villages (Table 5.1 a) whereas, minimum and maximum time was 5 and 9 hours, respectively. This shows that there was no such dilemma of sleep shortage in these regions, as people go earlier for sleeping due to tiresome work routine. And in mountainous areas, people avoid working and moving in late evening and prefer to sleep early. Moreover, in the sample areas there are no such provisions like cable, internet etc. where people can engage themselves for long after evening.

Per Day Time for Water Fetching is an important variable with regard to women time allocation. It is determined by the distance of water source. Average water fetching time in Bagh and Battagram was 4 and 6 hours, respectively. The average water fetching time in Battagram was higher by 2 hours, which was due to the higher average distance of water source from dwelling unit (Table 5.1 a). Minimum time required for fetching water reported in Bagh was 0.25 hour whereas; in Battagram it was one hour. Similarly, maximum time allocated to water fetching in Battagram was 12 hours a day while, in Bagh it was 10 hours.

Another important variable regarding water fetching is Persons Involved in Water Fetching. Study reveals that on average each household had 2 individuals who were fetching water in both regions. Single person in fetching water reflected as minimum number of water fetching individuals in both villages (Table 5.1 b). Maximum number of water fetching individual was 4 and 5 in Bagh and Battagram respectively.

Table 5.1 (b)

Average of Per Day Time for Water Fetching, Persons Involved in Water Fetching and Daily Saved Time

Regions	Per Day Time for Water Fetching (hrs)	Persons Involved in Water Fetching	Daily Saved Time (hrs) Due to RRWH System
Bagh	4	2	4
Battagram	6	2	6
Overall	5	2	5

Daily Saved Time in hours is a crucial variable of the present study. It is based on women saving of time which become possible after getting installed the RRWH System. Findings of the study yielded that in both villages women save on average 6 hours of daily water fetching time due to this facility (Table 5.1 b). Notably, minimum time saving was 2 and maximum was 10 hours in both study areas. Findings of the present study are in line with the study of Elizabeth, *et al.* (2006). It is worthwhile to mention that, this saving of time due to RRWH technology was being invested in productive activities by the women.

These activities includes, entertainment and social activities, agriculture and livestock, domestic work, education and awareness etc. (Table 5.1 c). Findings yields that women from Bagh are spending 20 percent of their saved time in entertainment and social activities which indicates that they have the social capital and they are doing investment to enrich it. Social capital plays a vital role in women welfare because, they discuss their daily life problems and get or offer help within their networks.

Contrary to Bagh, women in Battagram are not spending their saved time in social activities and have zero social interaction with other women in communities on regular basis. The reason behind this is that culturally women in Battagram rarely go out of their homes, so they cannot form such networks with other community members as of Bagh. This is important finding of the study because it indicates the strength of social networking in both regions.

Table 5.1 (c)

Saved Time Utilisation by Women

	%age of Average Saved Time Allocated for Different Productive Activities at each Location			
Regions	Entertainment and Social Activities	Agriculture and Livestock	Domestic Work	Education and Awareness
Bagh	20	26	34	20
Battagram	0	25	70	5

Agriculture and livestock is the main sector of rural economy everywhere in the world. Because it provides food, fiber, fodder and livelihood sources to rural population. Moreover, due to having enough available land and less off farm income opportunities, rural household prefer to cultivate crops for their sustenance. Study exposed that women are utilising almost 25 percent of their time saving in agriculture and livestock in both regions (Table 5.1 c). It means that agriculture and livestock is getting almost equal attention and share of women's saved time in Bagh and Battagram.

In domestic work women from Battagram are dominating over women of Bagh in allocating saved time. Study estimated that they are spending 70 percent of their saved time in domestic activities which is almost double of that in Bagh. The reason is that women from Battagram had no time allocation for social activities which is being used in domestic work. Moreover, they have less education and mobility out of their houses, which compel them to use saved time in domestic work. Education and awareness includes time allocation in getting formal or informal education, children tuition, or other awareness related activities at household level. It also grabs more attention of women in Bagh, because level of women education is higher in this area. They are spending 20 percent share of their saved time in education and awareness activities whereas; in Battagram it is 5 percent.

5.2. Econometric Analysis

Using OLS technique study analysed the impact of RRWH technology on women time allocation. Dependent variable is Total Work Time 'TWT' of water fetching women from early morning to night. Explanatory variables includes focused variable 'RRWH' and some controls. Study computed several models for women time allocation form model 1 to 4 with different specifications in order to check the robustness of the results. Model 1 is the baseline model that includes relevant variables.

Amongst the explanatory variables Rooftop Rain Water Harvesting 'RRWH' is a dummy which is used as proxy for 'RRWH' where '1' stands for treated group and '0' for the control group. It is the key or focused variable of the study and included in model to look into its impact on women total work time. Findings yielded that, 'RRWH' has positive relation with 'TWT', dependent variable. Positive sign of variable was expected and its value is significant. It is very prominent finding of the study, which means that total available work time excluding water fetching time has increased due to saving of time which otherwise invested in water fetching.

And that time is being utilised in productive activities like children brought up, agriculture and livestock, social activities and entertainment, and domestic work. Saving and productive usage of time has already been confirmed by the cross tabulations presented in descriptive findings' section. It is important to mention here that might be total saved time was not being fully utilised, but even if women are using part of that time saving, still it is resourceful and it enhances the wellbeing of communities which are using RRWH technology.

Region 'REGION' is also a dummy variable, included in analysis to investigate the regional difference of time allocation. The construction of this dummy is such that '1' represents Bagh and '0' symbolises Battagram. The variable is significant with negative sign which was expected. The reason of negative sign is that, both regions of the study are different with respect to socio economic and cultural aspects. For instance, as explained above education level is different in both districts. Additionally women access to health, education, nearest market and transportation service is comparatively better in Bagh as of Battagram. Moreover, regional income disparity is also found by the study, which is due to different levels of on and off farm available job opportunities and role of agriculture and livestock across the regions.

Table 5.2

OLS Model of Women Time Allocation Model

Variables	Model 1	Model 2	Model 3	Model 4
CONS	13.294	13.287	13.287	13.221
	(31.88)***	(32.00)***	(24.50)***	(33.11) ***
RRWH	1.910	1.907	1.913	1.921
	(6.74)***	(6.88)***	(6.88)***	(6.78)***
REGION	–0.984	–0.982	–0.864	–0.902
	(–3.16)**	(–2.42)**	(–2.40)**	(–2.92)**
AGES	0.018	0.018	0.018	0.021
	(1.57)	(1. 57)	(1. 58)	(1.63)
HHINC	–6.09e-06	–6.09e-06	–6.09e-06	
	(–0.47)	(–0.47)	(–0.47)	
SAT	0.112	0.112	0.110	0.111
	(0.67)	(0.69)	(0.67)	(0.68)
EDU	0.017	0.017		
	(0.38)	(0.38)		
DWS	–0.007			
	(–0.02)			
No. of Obs	370	370	370	370
R^2	0.1285	0.1285	0.1281	0.1277

Note: Robust *t*-statistics in parentheses. *Significant at the 10 percent level. **Significant at the 5 percent level. ***Significant at the 1 percent level.

Women Ages 'AGES' was included in model to identify the impact of women age on women time allocation. The variable was found to be insignificant with expected sign. The reason of insignificance of this variable is that on average women age was 33 years and data has reported less variation in women ages. From this, one may conclude that within this age group which comprised almost all young women, comparatively vulnerability to disease is very less, and could manage their domestic work easily. So women age has no affect on total work time.

Household Income 'HHInc' is very important variable engulfed in model. It is almost insignificant with negative sign which was expected. Since there were no such employments opportunities for women, where they can offer their services to market, they cannot avoid the household jobs. Secondly, there is no trend of hiring house maids and servants in those communities, due to which a women from household having higher income cannot use the services of someone else to reduce the time for domestic work. Thirdly, it is due to the social structure of male dominant society, where women have very less share in decision making. And they follow the set norms of society and do not demand more than what they have.

Social Activities Time 'SAT' is highlighted as a predictor of total work time. But this variable is also insignificant having lowest value of its coefficient. Reason of insignificance of this variable is that, when women go out of their homes for some work they get the company of other women, which is their SAT as well as work. For instance, when they go for shopping, fetching of water or herding their animals in range lands, they

get the company of their friends and neighbours. Due to this reason their social activities time cannot exactly isolated from their work time and is not significant in model.

Education of Women 'Edu' was taken in to model to analyse its impact on overall women time allocation pattern. Women education is insignificant in model and it has two reasons. One is that study have dominant sample from Battagram where there is almost zero education of women as compare to Bagh. Secondly, since all women in our sample are either housewives or the most responsible member of their household, they have to spend a good chunk of daily time for domestic work, and they cannot avoid it even if they are educated. Thirdly, over there women did not have such employment opportunities as of urban, so they prefer to manage their domestic work, because culturally every potential woman in rural household has to share the burden of family.

Distance from Water Source 'DWS' is comprised in model to examine its impact on time allocation. This variable is not significant because of shorter distance of water source. As the average distance of water source from dwelling unit is 1 kilometer that is not large for the people of hilly area. Secondly in each household there was more than one woman which was fetching water, so time of water fetching was distributed. Due to which it has no significant impact on overall time. Moreover, distance from water source is not the sole determinant of time allocation to water fetching and total work, but there are some other factors like nature of tracks and travel hurdles which determine the women time allocation.

R^2 shows the overall goodness of fit, which is significant in case of model 1. In model 2 study excluded the 'DWS' which has the lowest value of its coefficient and is not explaining the dependent variable. Exclusion of this variable has not altered the sign or significance of any variable. All other variables are remained same. In model 3, study dropped the 'EDU' which was also insignificant. Dropping this variable out of model, make no change in the sign or significance of any other variable in the model 4. So, we can say that this variable is also not a predictor of the women time allocation. Study eliminated the 'HHInc' from model 4 due to its insignificance. Elimination of this variable is also justified because still all variables are same with their sign and significance.

6. CONCLUSION AND POLICY IMPLICATIONS

Present study is the assessment of RRWH technology to investigate the impact of technology on women time allocation. Mainly there are two parts of the present study. First part is based on descriptive analysis which reports the potential of technology in saving the time of water fetching women. This part of the study has also reported that saved time of water fetching is being utilised by women in advantageous activities. In this regard level of awareness and understanding of the technology is found to be the most important determinant of effectiveness of the technology in terms of accruing the optimum benefits.

Second part is based on econometric analysis which yielded that there is significant positive impact of RRWH technology on women time allocation. Study exposed that technology has reduced the time allocation for fetching water. Findings endorsed that this system is very viable, profitable, women friendly, and sustainable source of water supply. The findings of the present study have following policy implications.

(1) Firstly, the technology is very useful because it is saving time which is being productively utilised. Therefore present study recommends that the technology should be extended and installed in all other areas.

(2) The system has special importance with reference to women well-being, because it reduces the time and fatigue involved in fetching water. Study proposes that women of those communities should be trained to utilise their saving of time for some productive activities.

(3) Present study has found that education and awareness of supported population played significant role in accruing the benefits of any development. Based on this finding, study proposes that in order to ensure the maximum benefits of any facility, beneficiaries should be educated and trained so that they could get maximum out of that.

(4) RRWH is environmental friendly in many respects like it increase water and soil conservation, ensure sustainable water supply, put less pressure on existing water sources, has no such negative externality, and enhances the poor's resilience against drought conditions. So in order to ensure environmental sustainability this technology should be promoted at large scale.

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