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RESEARCH NOTE

7.5 Crore Green Jobs? Assessing the Greenness of MGNREGA Work

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Abstract *The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) provides 'sustainable livelihoods' or 'green jobs' to workers engaged in restoring the rural ecology while contributing to 'sustainable rural development'. While the works constructed under NREGA possess tremendous potential to improve environmental indicators—rise in water levels, carbon dioxide sequestration, improvement in soil quality etc., it is unclear how much of that is actually happening. This study seeks to explore this question in this context. Firstly, the study finds that, on the whole, MGNREGA works are green and the works do ensure an overall improvement in environmental parameters. Secondly, several newly adopted activities (such as the construction of roads, buildings and wells) are actually not 'environmental' and hence, do not necessarily provide 'green jobs'. Despite the massive socio-economic contribution of these works, they can actually cause significant environmental damage. Therefore, it becomes important to balance the 'non-environmental' works with sufficient 'environmental' works. Finally, though this paper attempts to quantify the environmental impacts of MGNREGA works, it is limited by constraints of data availability, time and resources. However, it intends to push for a national effort to develop methodologies for inculcating environmental*

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sensitivity into the planning, design, execution, utilisation and evaluation of MGNREGA works. It is hoped that these exercises would significantly contribute towards the ecological restoration of rural areas by the MGNREGA.

Keywords MGNREGA · Green Jobs · Environmental Impact Assessment · Environmenal Planning · Green Index Construction · Assets

1 INTRODUCTION

Environmental concerns are often thought to be in conflict with the more immediate goals of poverty eradication and economic growth. A key policy challenge, therefore, is to find ways to meet these goals while preserving and enhancing our natural wealth. Rural development schemes, such as the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) provide a unique opportunity to meet this challenge.

The MGNREGA not only provides an average of 45 days employment to nearly 4.5 crore households (thereby helping to eradicate poverty), but also contributes significantly towards developing rural infrastructure. In 2013–14, 94.82 lakh works (new and spill-over) involving a total expenditure of Rs. 38,678 crores were ***taken up*** (an average of 37 works in each of the 2,53,189 village panchayats across India). In 2012–13 and 2013–14, the scheme provided employment to nearly 7.5 crore people across India and ensured the construction of nearly 25 lakh rural works anually (www.nrega.nic.in).

The massive numbers of works being undertaken in rural areas have the potential to not only transform the rural economy but also its environment. As quoted by the then Minister for Rural Development, "the Ministry of Rural Development's (MoRD) Schemes have an immense potential to contribute to the goal of sustainable poverty reduction and efficient use of natural resources, including improved land use planning and management practices" (Shah et. al. 2012). Comprising almost half of the MoRD's entire budget and focusing on works related to water, soil and land, the MGNREGA possesses the potential to ensure poverty reduction and environmental restoration.

That the scheme has contributed to economic growth, particularly in terms of improving agricultural productivity and creating livelihoods, has been established in literature (Bhaskar and Yadav 2015, Bhaskar et al. 2016). A number of studies have assessed the impact of MGNREGA works on agriculture, including changes in cropping area, intensity and productivity (Bhaskar 2008; Aggarwal et al. 2012; IIFM 2010; MPISSR 2010; Shah et al. 2011; Verma et al. 2012).

However, whether MGNREGA works have actually fulfilled their goal of contributing towards environmentally sustainable development is still unclear even a decade after its enactment. The MGNREGA Sameeksha Report, an anthology of studies on its impact, notes: "Preliminary findings indicate that MGNREGA works have led to a rise in groundwater, improvement in soil quality and reduction in vulnerability of production systems to climate variability (by strengthening livelihood and water security)" (Shah et. al. 2012: 39). The report concludes: "the existing literature suggests that MGNREGA has had a positive impact at the micro level" (Shah et. al. 2012: 38). However, this conclusion is possibly rushed or even biased because most studies evaluating the scheme's environmental impact still face two critical limitations.

First, they only assess the environmental impact of "natural resource-based works" or "environmental works", such as check dam or stop dam construction, restoration or desilting of ponds, percolation tanks or tanks, silt application, tree plantation, land terracing and contour/graded and field bunding (IISc 2013). Such works constitute only about 48% of the works taken up[1]. However, increasingly, the majority of the MGNREGA works seem to be less natural resource-based. Instead, they comprise works such as, construction of roads, toilets, panchayat bhavans, cremation structures, play grounds, etc. Environmental evaluations of such ‘non natural resource-based’ and material intensive works are as critical as those of natural resource-based ones. However, such an evaluation has not been undertaken thus far.

Second, these studies only examine certain selected parameters, choosing to ignore its impact on others. For instance, when studying the impact of wells, they examine their impact upon the availability of water for domestic and agricultural use, but not on ground water levels or atmospheric emissions arising from their construction and use (Bhaskar and Yadav 2015, Bhaskar et al. 2016). Similarly, when studying the construction of tanks, they only consider its positive impact upon ground water recharge and the increase in the availability of water for irrigation. Its impact upon atmospheric emissions arising from the production and transportation of materials used in its construction or from the use of motors to extract water for irrigation is, however, ignored (Tiwari et al. 2011; IISc 2013; Esteves et al. 2013). In other words, most studies have focused on MGNREGA’s ‘potential’ to improve certain local environmental indicators, rather than assess the overall impact of the programme.

2 THE NEED FOR THIS STUDY

While the contribution of existing studies is extremely important, a more comprehensive environmental analysis of MGNREGA activities is urgently required for three primary reasons.

First, MGNREGA is recognised as an “ecological act” that “aims at eradication of extreme poverty and at making villages self-sustaining through the creation of productive works. This is meant to regenerate the rural natural resource base, which in turn will result in sustainable livelihoods for residents” (CSE 2008: iv). Whether the programme achieves this aim or not cannot be answered by ignoring the environmental damage that is inevitable in the case of most human activities, including the construction and use of MGNREGA works.

Second, any attempt at maximising the environmental gains from MGNREGA must be accompanied with efforts to acknowledge and minimise environmental losses. The MGNREGA Sameeksha Report notes: “the true potential of MGNREGA as a Green Scheme can be fully realised if additional parameters are included in planning and implementation, to focus on activities specifically from the point of view of environmental sustainability and decent work, such as use of resource efficient materials at work sites etc.” (MoRD 2012: 42). To use more resource-efficient materials for construction, however, one must first acknowledge that certain materials can significantly impact the environment.

[1] Source: http://mnregaweb4.nic.in/netnrega/all_lvl_details_dashboard_new.aspx.

Third, to realise its true ‘green’ potential, the environmental impact of individual MGNREGA works must be considered while planning their mix. A partial view of the impact of these activities may lead to an unsustainable mix of works. For instance, if the prevention of soil erosion is understood as the only environmental impact of building roads and increase in agricultural productivity and output is understood as the only environmental impact of constructing wells, it may increase road and well constructions under MGNREGA. Though this may prevent soil erosion and increase crop output, it may result in a rise in pollutant emissions even as the ground water depletes.

This study, therefore, develops and illustrates the application of methodologies for a comprehensive environmental evaluation of a few selected MGNREGA works. Moreover, it proposes a methodology to develop a Green Index—a single figure that captures the overall impact of any MGNREGA asset on air, water, soil and agricultural productivity. Such an index would facilitate a comparison of environmental impact of different works and enable estimation of the overall environmental impact (positive or negative) of MGNREGA activities within a panchayat, block, district, state or country. Such endeavours could drive better planning of the asset mix, so the works with negative environmental impact could be combined with other environmentally positive activities, thereby ensuring that the overall environmental impact of all MGNREGA works stayed positive.

The study departs significantly from previous studies of a similar nature, in acknowledging that the nature of MGNREGA works is changing and many of the newly conceived works are not necessarily ‘environmental’ or ‘natural resource-based’ works. In fact, they can contribute significantly to environmental degradation. Even the so-called natural resource-based works can sometimes have a mixed effect on the environment i.e., significant negative effects on some environmental parameters (such as air quality) while improving other environmental parameters (such as ground water levels).

It must be noted that this study does not discuss several of the socio-economic impacts of MGNREGA works other than the ‘greenness’ of the jobs created by the construction activities nor does it belittle the significance of such impact. Most MGNREGA works have massive potential socio-economic benefits, even if their environmental impacts may be negative. Roads, wells, toilets and several such activities are not designed to have any environmental benefits, but rather to meet socio-economic objectives. A rural road, for instance, may very well transform the lives of the residents of a rural hamlet which was earlier inaccessible for vehicles. Similarly, an irrigation well may transform the life of the well owner, as his or her income from agriculture may increase manifold. This study does not discount the importance of these activities or the socio-economic objectives that they fulfil.

3 SELECTION OF STUDY AREA

The study is located in Madhya Pradesh (MP). In order to account for agro-climatic diversity, the state was categorised into two regions – districts with above-average and below-average rainfall. To select districts with the maximum MGNREGA works, each district in MP was assigned an index comprising two parameters – the number of completed works and the total expenditure on the MGNREGA activities. Then the study selected districts with the highest index score from amongs the above-average rainfall districts (Chhindwara) and the below average rainfall districts (Sehore).

An index (using total expenditure and number of works) was created for each type of work within each district. The index enabled the authors to select the five most popular works in Sehore and Chhindwara: Land Development (Bhumi Shilp), Private Wells for Irrigation (Kapil Dhara), Toilet Construction (Nirmal Vatika), Fruit Tree Plantation on Private Lands (Nandan Phalodyan) and Cement Concrete (CC) Road Construction (Panchparmeshwar CC Roads). These five activities together comprised 91.2% of the total completed works in the two districts.

Two blocks within each district and two panchayats within each block were finally selected on the basis of an index that represented the number and diversity of these MGNREGA works. Finally, one asset from the five types mentioned above was selected from each of the eight panchayats. Thus, in total, 40 MGNREGA works were studied.

4 METHODOLOGY OF THE STUDY

This section briefly summarises the methodologies used to calculate the impact of the five selected MGNREGA works on three components of the environment—air, water and soil. For a detailed description of each methodology, please refer to the detailed report (SPS 2014).

4.1 Calculating the Impact on Air

The impact on the air from the construction and use of MGNREGA works is measured in terms of Carbon di oxide equivalents (CO_2e) emissions (the amount of CO_2 which would have an equivalent global warming impact). Thus, while the activity may lead to the production of different gases, such as carbon oxide, nitrogen oxide, sulphur oxide and hydrocarbons, what is important is their Global Warming Potential (GWP), measured by their carbon dioxide equivalents (CO_2e). This allows "bundles" of Green House Gases (GHGs) to be expressed as a single number and enables easy comparisons with each other in terms of their total global warming impact. While this method enables the authors to add and compare gases, it has one serious limitation: Gases can impact, other than influence global warming, on the local environment. For instance, carbon monoxide, particulate matter, lead and its oxides (released by burning fossil fuels) may not significantly impact global warming but can severely impact health. This study's indicator measures the 'warming' impact of GHGs but not the other kinds of impact of these gases.

4.1.1 GHG emissions during construction of the asset

The construction of the MGNREGA works requires materials, such as sand, stones, iron and cement, the production and transportation of which can take a heavy toll on the environment. These costs are calculated using the formula in Table 1. The total GHG emissions due to the construction of the asset are calculated as the sum of:

1. Emissions due to the production of the materials used in the asset (column 4)
2. Emissions from the transportation of materials (column 5)

4.1.2 GHG emissions from the use of the asset

Post construction, the use of these works may also lead to emissions over their lifetime. For instance, the use of wells to extract water would lead to emissions if the water is drawn using a mechanical pump or motor. Tree plantations, for instance, would also mandate extensive watering, at least during the first five years after planting till they reach maturity. This is why works like farm bunds were undertaken so that they could reduce the irrigation requirements of farms, thereby containing emissions through reduced use of mechanical pumps. The additional CO_2e emissions (or savings due to an asset) are estimated as shown:

Total CO_2e *Emissions (or reduction in emissions) from machinery used in a year*	=	*Litres of diesel consumption (or reduction in diesel consumption) in a year*	×	*2.68 kg of* CO_2e */ litres of diesel*

4.1.3 Impact of carbon sequestration

Carbon sequestration increases with increase in tree cover. However, tree plantation and their maintenance involve activities such as consistent watering and the use of chemical fertilisers and pesticides. The net, long-term impact of the plantations on the atmosphere must, therefore, account for all these factors. While the emissions due to the use of motors for drawing water were found to be significant, those attributed to the use of chemical fertilisers and pesticides were found to be insignificant given the very small quantities of chemicals used in plantations surveyed for this study. Hence, the latter were not included in the estimations. The study found that the planting of trees around farm bunds, toilets and on the sides of roads could also positively impact carbon sequestration, albeit to a lesser extent. On the other hand, clearing trees to build roads could reduce carbon sequestration. However, given the inadequate information on the number of trees planted and their survival rates, the authors were unable to measure the net carbon sequestration impact for these works.

Table 1 Emissions due to production of materials used in the construction of the asset

Material	Emission factor during Production (Column 2)	Source	Total emissions from production of quantity used in Construction of the Asset (Column 4)	Emissions from transportation
Cement	0.86 kg of CO_2e per kg of cement produced	Gilani (2012)	0.86 × Quantity of cement used (in kg)	Number of truck loads of cement bags × Average distance of cement plant from worksite (to and from) × 2.68* Average mileage of truck
Sand	0 (Since sand extraction is done manually)	Field observation	0	Number of tractor loads of sand × Average distance of sand extraction site from worksite (to and from) × 2.68 Average mileage of tractor
Stone	10.9 kg of CO_2e per 100 cft of stones produced	Field observation	10.9 × Quantity of stones used (in tractor loads)	Number of tractor loads of stones × Distance of stone production site from worksite (to and from) × 2.68 Average mileage of tractor
Iron	0.7 kg of CO_2e per kg of iron produced	INCCA (2010)	0.7 × Total quantity of iron used (in kg)	0.3 kg of CO_2e per kg of iron used (based on a set of assumptions regarding source of iron and its average distance from worksite, as data on source of iron is not available)
Bricks	0.22 kg of CO_2e per kg of bricks used	Gilani (2012)	0.22 × Number of bricks used (one kg each)	Number of tractor loads of bricks × Average distance of brick kiln from worksite (to and from) × 2.68 Average mileage of tractor

In the absence of reliable estimates on the emissions from crushing and transportation of stones, we used estimates for energy consumption gathered through field work and observation at a stone crushing plant in Semari Panchayat, Budni Block, Sehore District of Madhya Pradesh. The owner of the plant described that the plant used nearly 200 litres of diesel per day to produce approximately 5600 cft of stones. Further, the plant sourced its raw material from hills nearly four kilometres away. Therefore, 100 cft of stone would require 200/5.6 = 3.571 litres of diesel. Transportation from source, loading, unloading requires approximately 0.5 litres of diesel per 100 cft of stone. Total diesel consumption per 100 cft stone = 3.571 + 0.5 = 4.071 litres. Emissions from diesel required to produce 100 cft stone = 4.071 × 2.68 = 10.91028 kg of CO_2e emissions

*Combustion of one litre of diesel is estimated to produce 2.68 kg of CO_2e emissions (Gilani 2012)

Most of the plantations undertaken under MGNREGA in MP are young and have not reached maturity (typically trees were not more than 3 years old and hence, had not attained a height of more than 5–7 feet). Thus, destructive methods that were generally used to measure carbon sequestration, such as those which required the removal of a wood sample to measure wood density and thereby tree biomass, were deemed inapplicable. In order to measure the carbon sequestration potential of the trees, therefore, the authors used the following formula:

CO_2 *sequestered by the Plantation*	=	CO_2 *sequestered by a single tree (278.3 kg)*[a]	×	*Number of trees which are expected to survive to maturity.*

[a] CO_2 sequestration depends on a multitude of factors ranging from tree species, growth, extraction practices, etc. We make use of ESD (2008), which estimates the carbon sink potential of mango trees over their lifetime and apply these estimates to other fruit tree species. The potential carbon sequestered by a mango tree over its lifetime is estimated to be around 30.78 tonnes C/hectare, where each hectare consists of 400 mango trees. Further, the carbon sequestration potential of cultivated/cropped land is estimated at 0.42 tonnes C/hectare. Thus, the net carbon sequestered by one hectare of plantation which has led to the removal/clearance of the same amount of agricultural land is 30.78 − 0.42 = 30.36 tonnes. The carbon sequestration potential of a single tree, therefore, can be estimated to be 30.36 tonnes/400 = 0.0759 tonnes. The CO_2 sequestration can be calculated by multiplying this by 3.67 (since a CO_2 molecule is 3.67 times the weight of a carbon atom), which amounts to 278.3 kg CO_2 sequestered by a single tree over its lifetime

4.2 Calculating the Impact on Water

4.2.1 Calculating the impact on groundwater levels and water usage

The authors could not calculate the impact of a single MGNREGA asset upon ground water levels since there were multiple forces influencing ground water levels. So, instead, the authors estimated the change in the amount of water being extracted (or recharged) from (or into) the ground. Doing this entailed asking the beneficiary whether more (or less) water was required as a result of the asset.

4.2.2 Net change in ground water extraction due to wells

While wells are an extremely important asset, they may also cause a depletion of ground water. The rate of extraction of water from the well and the total duration of its use were estimated based on interviews and field observations. Then the total water extracted from a given well over a year was calculated:

Total extraction of water from a well in a year	=	Rate *of extraction (litres per minute)*[a]	×	*Total duration of well use in a year*

[a] Rate of extraction of 42.9 l per minute using a 1.5 HP motor has been arrived through direct observation and measurement of the amount of water discharged by a 1.5 HP motor on the field of Vishal Jagannath, Hasanpur Tinoniya, Sehore Block, Sehore District

However, wells are also likely to lead to a small increase in the recharge of ground water given that rainwater falling inside the well goes directly into the ground. The quantity of water recharged due to the well can be calculated as:

Total annual recharge of ground water due to the well	=	*Cross Sectional Area of the well*	×	*Total rainfall in the year (in cm)*

Using the above results, it is possible to measure the NET annual amount of water withdrawn from the well:

NET annual amount of water withdrawn from the well in one year	=	*Total water extracted annually*	−	*Total Annual Recharge*

4.2.3 Net change in ground water extraction due to tree plantations

Tree plantations require watering and ground water extraction is imperative. The total water extracted in a year may be similarly calculated as:

Total extraction of water for watering of plantation in a year	=	*Rate of extraction (litres per minute)*	−	*Total duration of motor-use in a year*

4.2.4 Net change in ground water extraction due to farm bunds

It is claimed that the construction of bunds around a farm can reduce run-off and increase infiltration of water into the ground, particularly, if trees or bushes are planted around the farm bunds to bind the soil. Reduced run-off implies water savings through lowered irrigation requirements. The actual impact upon ground water recharge is largely a function of the way the bund is constructed. The water saved due to farm bunds can be calculated as:

Water saved due to farm bunds in a year	=	*Rate of extraction (litres per minute)*	−	*Reduction in duration of motor-use for irrigating the field in one year*

4.3 Calculating the Impact on Soil Quality

Among the MGNREGA works considered here, three works – namely tree plantations, farm bunds and toilets – are likely to significantly impact soil quality.

Farm bunding can reduce run-offs, thereby lower soil erosion and increase the moisture content of the soil. This preservation of nutrients is likely to lead to an increase in agricultural productivity. In the case of toilets, organic compost prepared from human waste could improve soil quality through an increase in Soil Organic Content (SOC) and Soil Moisture Content (SMC). Finally, if tree litter is allowed to decompose in the soil itself, tree plantation may also increase the SOC and SMC. The tree roots may absorb nutrients from the soil, thus, reducing nutrient content but they may prevent soil erosion and contain loss of nutrient-rich top soil.

Roads are un likely to significantly impact soil quality. Wells are equally unlikely to directly impact soil quality too, although they may indirectly have an impact due to the change they introduce into agricultural practices.

Therefore, for the purpose of this study, the impact of toilets and tree plantations has been estimated through an SOC analysis on the beneficiary and the control plots. The impact of farm bunds on the soil was assessed in terms of the change in agricultural productivity. The perceptions of the beneficiaries have been included to assess the changes in agricultural productivity brought about by farm bunding.

5 RESULTS

The previous section proposed a methodology to estimate the impact on air, water and soil quality for five of the most popular NREGA works undertaken in Madhya Pradesh. The results of this application have been illustrated here. However, as discussed earlier, it was difficult to quantify an asset's potential environmental impact. This section, therefore, discusses the impact, which has not been quantified.

5.1 Farm Bunding

It has been three years since Harbhajan Singh Dhurve's request for undertaking farm bunding work on his farm in Tendini Panchayat, Chhindwara was approved and fulfilled under NREGA. Three feet high bunds were constructed on his farm by employing 70 person days of labour and spending Rs. 45,000 on wages. These bunds improved the soil quality tremendously and this was evidenced by nearly two-fold increase in agricultural output post land-levelling and bund-construction. While the soil organic carbon content of his farm is actually lower than the surrounding non-bunded farms, his output for crops like ginger, onions, green peas, masoor, carrots, gram, maize and wheat rose considerably, indicating a significant improvement in soil quality due to the bunds. Now, Dhurve uses lower amounts of fertilisers, since the farm bunds have lowered the chances of soil erosion enabling the unabsorbed fertiliser to remain in the soil.

Moreover, the bunds have led to savings of nearly 155 kilolitres of groundwater annually due to lower water run-offs and an increased retention of water within the field. For Dhurve, this means that he needs to water his fields for only half of the duration than before.

Lastly, less water extraction means less use of the pump set to draw water. This reduced fuel combustion has led to a reduction in diesel emissions during water extraction by about 0.16 tonnes of CO_2e per year. Unlike many other works, the construction of the bunds did not lead to any significant emissions, since they were built manually using mud from the farm itself and so, did not use of emission-intensive materials or machinery.

Overall, the survey of farm bunding works revealed that they had improved soil productivity, reduced the need to extract ground water and thus, reduced emissions from mechanical water pumps. The precise quantum of the impact has, however, varied greatly across panchayats, blocks and districts, depending largely upon the quality of the bunds and their maintenance by the beneficiaries. The average value of these impacts across the eight farm bunds surveyed is presented in Table 2.

5.2 Tree Plantation

Gulab Singh, from Ratanpur panchayat in Sehore, received 100 saplings of guava and sweet lime under the Nandan Phalodyan sub-scheme of the MGNREGA. Transportation of the saplings, from a nursery nearly 250 kms from his village, would have led to approximately 250 kg of CO_2e emissions. Since the time Gulab Singh planted the saplings, he has spent nearly 50 hours every year watering them. The plants need to be watered extensively only over the first five years, till they reach maturity, after which they potentially draw nearly 6,03,500 litres of water. He draws water from the well using a pump, which is estimated to cause CO_2e emissions of nearly 670 kg over the initial five years. The trees were planted on his farm, where he continued to grow wheat, gram and mulberry. Therefore, there was no reduction in the carbon sequestration potential of the land due to the removal of crops. Of the 100 trees planted, 10 died due to poor quality of the saplings, while the 90 that survived had a high possibility of reaching maturity (having survived for over four years). These plants have the potential to sequester nearly 25,388 kg of CO_2 over their lifetime. The net CO_2 sequestration potential by the plantation, therefore, after subtracting the potential emissions due to the use of water pump, is around 24,5009 kg (i.e. nearly 24.5 tonnes of CO_2 sequestered over its lifetime).

Table 2 Environmental impact of farm bunding

Average height of bunds	2.5 feet (at the time of the survey)
Average area covered by bunds	1.3 Hectare
Average annual reduction in water required for agriculture (litres)	2,04,204.00 (33% reduction)
Average reduction in CO_2e emissions (kg)	416.74
Average reduction in use of fertilisers	20%
Average increase in crop productivity	20%
Non quantified impacts	
Increase in ground water table due to greater infiltration of water and lower run-off	

Of the 11 tree plantations for which data was used, 10 were undertaken on private land under the Nandan Phalodyan sub-scheme and one was on community land. However, the picture is not all green. Data from the 11 plantations suggest that saplings normally are required to be transported from nurseries over long distances, leading to emissions from fuel combustion (on average, nurseries were 77 km from the site of the plantation, which led to 17 kg of CO_2 emissions). Tree plantations require a large amount of water (an average of 5.2 crore litres of water over the first five years of their plantation), the extraction of which leads to considerable emissions. According to the estimates, an average plantation (with 340 trees expected to mature) would lead to the sequestration of 49 tonnes of CO_2 over an expected lifetime of 100 years. Further, tree litter (dried leaves etc.) falling on the soil and mixing with it could lead to an average increase in Soil Organic Carbon by 0.5%. The figure derived by using data from private plantations alone was significantly different. Private plantations (with an average of 122 trees expected to survive) lead to sequestration of 17 tonnes of CO_2 over an expected lifetime of 100 years. These CO_2 sequestration figures have been calculated after subtracting the emissions from fuel combustion while extracting ground water using pump-sets.

Tree plantations can have a range of other important effects on groundwater level soil erosion, evapo-transpiration and temperature reduction, which cannot be measured in this study given its limited scope and duration. The detailed findings related to the environmental impact of tree plantations are given in Table 3.

5.3 Toilets

Raoti Dehriya's life has changed since a toilet was sanctioned to her in 2010 under the Nirmal Vatika sub-scheme of MGNREGA. Dehriya and several other owners of toilets constructed under the scheme, now do not have to walk long distances and defecate in the open anymore. It is clear that toilets played a very crucial role in reducing their vulnerability to health ailments that arose due to open defecation.

The production and transportation of materials (bricks, cement, sand, stone and iron) used in the construction of Dehriya's toilet led to approximately 0.37 tonnes of CO_2e emissions. The largest contribution to these emissions came from the production and transportation of cement.

Under the Nirmal Vatika sub-scheme, Dehriya was provided with five saplings to be planted near the toilet, of which one died and four survived and are expected to reach maturity. The four surviving trees would potentially sequester nearly 1.1 tonnes of CO_2 over their lifetime. Over their collective lifetimes, therefore, the toilet and the accompanying trees would lead to net CO_2e emissions of nearly 0.76 tonnes. The compost taken out from the soak pits was spread in their backyard, which led to an increase in soil organic carbon of around 0.04%.

On average, toilets constructed under NREGA led to 1,6425 kg of CO_2e emissions and an increase in SOC of 0.04 % on the beneficiaries' plots. These findings are summarised in Table 4.

Table 3 Environmental impact of tree plantations (from 10 private and 1 community plantation)

Average number of trees surviving in a plantation	339
Average area of a plantation	1.33 hectare (1,43,518.67 sq.ft.)
Average net CO_2 sequestration potential of a plantation over its expected lifetime (kg)	49,067.02
Average net CO_2 sequestration potential of ***private*** plantations under the Nandan Phalodyan scheme (kg)	17,122.3
CO_2 sequestered by the community plantation (kg)	3,68,514.4 (3.68 lakh kgs)
Average quantity of water consumed by a plantation (litres)	5,22,09,687.3 (5.22 crore litres)
Average increase in Soil Organic Carbon due to tree plantation (weighted by area of plantation) (%)	0.05
Other non-quantified impacts	
Reduction in soil erosion and consequent improvement in soil moisture, DHA etc	
Reduction in water run-off leading to greater infiltration of water into the ground and rise in water levels	
Increase in evapo-transpiration and hence, decline in local temperatures as well as increase in possibility of rains	
Improvement in income, which leads to enhanced capacity to adapt to climate change in the long run	

5.4 Wells

Since 2012, Budhiya Bai's wheat output from her farm has nearly doubled from eight quintals to 15 quintals. She has also seen an unprecedented output of potatoes (230 kg) by planting the same amount as earlier (nearly 50 kg). Last year was the first time she planted anything during the summer (something uncommon in Bitta village of Chhindwara, where she resides). All this was possible due to a well that was constructed on her land under the Kapil Dhara sub-scheme of the MGNREGA. The well was constructed using 4500 kg of cement (90 sacks), 800 kg of iron bars, 1200 cft of stone and 600 cft of sand. The production and transportation of these materials would have led to nearly five tonnes of CO_2e emissions. She draws water from the well for nearly 360 hours in a year using a pump-set, which leads to nearly four tonnes of CO_2e emissions per year. The well has a surface area of 24 sq. ft., which enables nearly 725 litres of ground water recharge per year (given that the annual average rainfall in the region is around 120.172 cm). The net amount of water extraction per year (total extraction minus total recharge through rainfall),

Table 4 The average environmental impact of toilets

1. Average net CO_2e emissions in construction of toilets (kg)	1642.4
2. Average increase in SOC of plot due to compost application (%)	0.04
3. Area of plot on which compost was applied	100 sq. ft.
Non-quantified impact	
4. Environmental Health Indicators (e.g. Pathogen Concentration in the Air)	

Table 5 Environmental impact of wells

Net water drawn over a 20 year lifetime (litres)	9,84,468
Average increase in crop species cultivated per owner	2
Average increase in number of seasons cropped per owner	1.125
Average increase in area over which there has been an increase in cropping intensity (acres)	3.07
Average increase in net CO_2e emissions from each well (kg)	14,525
Non-quantified impact of wells	
Increase in agro-biodiversity may also lead to improvements in soil quality, if the farmer chooses the crops wisely	

Table 6 The environmental impact of road construction

Average dimensions of roads	Length (100m), Breadth (3m), Height (0.15m)
Net CO_2e emissions from road construction(kg)	13,202
Reduction in green cover (acres)	0
Non-quantified impact of road construction	
Concrete has a lower albedo effect (solar reflectance) than, say mud, and hence, would lead to an increase in heat absorption. CC roads could thus lead to an increase in local temperatures	
Increased motor vehicular traffic due to road construction and consequent increase in emissions	
Reduction in emissions due to ease of traffic flow and hence, lower fuel consumption	

therefore, is around 1235 kilo litres. Further, since Budhiya Bai has started growing crops during summer, the CO_2 sequestration potential of her farm has increased by around 0.6 tonnes.

Budhiya Bai's case depicts the massive socio-economic benefits for those who have access to wells. The results here do not discount these benefits but also attempt to highlight their lesser-recognised environmental impact. On average, the construction and use of MGNREGA wells were found to produce nearly 14.5 tonnes of CO_2e emissions (after subtracting the increase in carbon sequestration potential due to increased intensity of agriculture). Further, an average MGNREGA well was found to lead to net extraction of nearly 10 lakh litres of ground water over the course of its 20 year life (Tables 5, 6).

5.5 Road Construction

A 103 metre long CC road was constructed in March 2014 under the Panchparmeshwar sub-scheme of MGNREGA in Andhol village in Chhindwara, MP. Before the construction of the road, it would take nearly half an hour to get from one side of the village to the other; now it takes less than a minute.

The construction of the road has also led to a tremendous increase in vehicular movement between the two ends of the village. The production and transportation of material used to construct the road led to nearly 20 tonnes of CO_2e emissions, of which 17 tonnes of CO_2e emissions were caused by the use of cement alone, and the rest, due to sand and stones.

On average, CC roads (of a standard length of 100m) constructed under MGNREGA are associated with nearly 13.2 tonnes of CO_2e emissions. Most roads that were studied, were constructed on pre-existing earthen roads. Hence, there was no reduction in the green cover associated with their construction.

6 DEVELOPMENT OF A GREEN INDEX

The quantification of the environmental impact of MGNREGA activities, as illustrated in previous sections, enables us to validate whether the works constructed under the programme actually contributed towards 'greening rural development', mitigating climate change and building climate resilience. Moreover, it enables us to plan a mix of MGNREGA works so as to meet the overall objective of improving environmental indicators. To achieve this latter objective, it is important to have a measure, which allows the environmental impact of different works to be easily compared. Attempts at creating a Green Index for MGNREGA works have been made earlier. For instance, MoRD and UNDP (2012) developed an MGNREGA "Green Index as a part of the scheme monitoring system to track green impacts at the Gram Panchayat level". The index is useful and extremely practical as it considers differences in quality, coverage, durability and efficacy of these works. However, it suffers from many disadvantages and does not present a method of accounting for 'non environmental' works, nor does it allow for inclusion of negative environmental impact of activities.

The **Green Index** developed here is a simple, yet highly effective tool to increase sensitivity about the environmental impact of the five MGNREGA works covered in this study i.e. wells, tree plantations, roads, toilets and farm bunds. The index considers the impact of these activities on the following environmental parameters:

1. **Water Usage:** Measured as the Net Reduction in Water Usage (Reduction in Water Usage – Increase in Water Usage) attributable to the asset
2. **Green House Gas Emissions:** Measured as Net Increase in CO_2 Sequestered (Increase in CO_2 Sequestration – Increase in CO_2 Emissions) attributable to the asset
3. **Soil Quality:** Measured as the increase in Soil Organic Content of the beneficiary's plot as compared to a similar plot, which was not impacted by the asset
4. **Soil Productivity**: Measured as the increase in agricultural output due to improvement in soil quality (not due to increase in availability of water or increase in SOC).

For all four of these parameters, the positive values denote a positive environmental impact. The steps involved in the calculation of the Green Index are outlined below:

Step 1: Averaging the values of the environmental parameters
The average impact on each environmental parameter is calculated separately for each asset.
Step 2: Standardisation of the average measures
The average values calculated above are then divided by the Highest Average Value for each parameter from among the five works. This indicates a scale neutral measure of the environmental parameter, where the highest value is taken as 1 and the values for other works are relative measures of their impact on that parameter.
Step 3: Scaling of the Average Measures
The standardised values are scaled up or down depending upon the average area of influence. For instance, the Green Index value of 1 for tree plantations refers to a plantation of 338 fruit trees. However, a larger plantation, of 676 trees for instance, would have a Green Index value of 2.
Step 4: Construction of the Green Index
The scaled values of the environmental impact across indicators for an asset are then added up to arrive at a measure of the Green Index for the asset. This method of adding attributes attaches an equal weight (and hence, equal significance) to each of the environmental parameters being considered here. This is a rather arbitrary decision taken by the authors to facilitate an aggregation of impact across environmental parameters (an alternate methodology could include the use of participatory tools to assess weights attached by the respondents to different environmental parameters).

The environmental impact for each indicator and each asset, along with the Green Index for each asset are presented in Table 7.

This Green Index thus created, is limited by the fact that all four environmental impacts are weighed equally on the same scale (i.e. with values between −1 to +1). However, despite its constraints, the Index serves two purposes: First, it describes a method by which impacts across environmental parameters and works can be aggregated to evaluate the potential impact of a set of MGNREGA activities. Second, it breaks the myth that MGNREGA constitutes only, or even mostly of 'green activities'. In fact, two of the most popular activities, i.e. construction of wells and roads, have negative net impacts upon the environment. The Green Index calculated thus, enables us to plan MGNREGA activities so as to ensure that the overall impact on the environment is positive. For instance, it shows that the negative environmental impacts of three irrigation wells can be balanced by construction of a farm bund that is three feet in height and covering an area of 1.3 hectares. Similarly, the negative impact of five CC roads can be balanced by a single tree plantation with around 339 trees. Also, if a panchayat decides to construct one asset of each of the five types, the overall impact will be positive (since the overall Green Index value is 1.47).

The Green Index for each asset can be summed across the works to arrive at the overall Green Index value. Similarly, the values of all MGNREGA works in a panchayat, district or block can be summed to arrive at the corresponding Green Index value for that area. For instance, the Andhol panchayat in Chhindwara with

Table 7 Calculation of green index

	Wells	Tree[a]	Toilet[b]	Road[c]	Bund[d]
Net water recharge	−0.02	−1			0.004
Increase in soil organic carbon		1	0.0002		
Increase in carbon dioxide sequestered	−0.3	1	−0.03	−0.15	0.01
Increase in agricultural productivity due to improvement in soil quality (other than due to increase in soil organic carbon)					1
Green Index	−0.3	1	−0.0298	−0.2	1

Data could not be obtained on all parameters for all the works, as some of them did not meet the criteria required for measurement of the particular impact. These effects have not been quantified and included in the calculation of the Green Index

[a] One tree plantation refers to a plantation of 338 trees with an area of influence of 1.3 hectares (i.e. area over which an increase in SOC takes place)

[b] Area of influence of toilets is 100 sq. ft

[c] One road work refers to a CC Road of 100m length, 3m width and 0.15m height

[d] One farm bunding work refers to a bund three feet in height and covering an area of 1.3 hectares

five wells, one road, one tree plantation work, 41 farm bunds and 187 toilets would have an overall Green Index score of 34.7 [5×(−0.3)+(1×1)+187×(−0.03)+1×(−0.2)+41×1=34.7]. The Green Index for Sehore and Chhindwara was thus calculated, and found to be 17 and 3158, respectively. The difference was attributed to the dominance of 'environmental' works in Chhindwara (such as farm bunds and tree plantations) as opposed to the dominance of non-environmental works in Sehore (such as roads, toilets and wells). Out of all panchayats surveyed, only one Panchayat, Semri in Sehore district, had an overall negative Green Index value of −10.8. This was because the only work undertaken here was the construction of 36 irrigation wells.

7 CONCLUSIONS AND THE WAY FORWARD

To summarise, this study suggests that the MGNREGA is actually fulfilling its tremendous potential for creating 'green jobs' and 'greening rural development', as revealed by the Green Index values of the two sample districts. However, it needs to be realised that some MGNREGA jobs are not green jobs as the assets created have a net negative impact upon important environmental parameters, such as ground water levels and the atmospheric GHG levels. There are three major reasons for this.

First, increasingly, the numbers of works being undertaken under MGNREGA are not 'environmental' or 'natural resource-based' but are resource- and material-intensive, such as wells, toilets and roads. The MoRD had, in 2014, also expressed its intentions to lower the required labour: material ratio from the current 60:40 to 51:49 (Abreu et al. 2014), to be able to use MGNREGA for the construction of more 'durable' works. These changes, notwithstanding their socio-economic implications (positive or negative), are highly likely to increase the proportion of material-intensive works and thereby further increase the overall negative impact of MGNREGA on environmental indicators. A Green Index can be useful in planning a mix of MGNREGA works that have an overall positive impact on environmental indicators. Works, which are likely to lead to a decline in the water table, such as wells, can be combined in the appropriate proportion with works, which are likely to raise groundwater levels, such as ponds, check dams and farm bunds. Similarly, works likely to lead to large GHG emissions can be combined with works, which reduce emissions, primarily, tree plantation works.

Second, the study found an acute lack of awareness regarding the environmental objectives of MGNREGA activities which severely hampers certain works from attaining their potentially positive impact on the environment. For instance, under the Nirmal Vatika sub-scheme of the MGNREGA, toilets have two soak pits to facilitate composting of excreta, which if applied to fields can increase soil productivity by improving its organic content and moisture retention capacity. However, the authors found that most beneficiaries were completely unaware of this. On the other hand, wherever communication for behavioural change was taken up seriously, it was found to reap massive benefits. For instance, during the survey, the authors found very little open defecation in Budni, one of the sample blocks. On further investigation, the authors realised that the success in reducing open defecation in the block could be attributed to the Maryada Abhiyaan, a pilot campaign of the MP government to use MGNREGA to eliminate open defecation by making use of behavioural change communication as envisaged in Community-led Total Sanitation (Hueso et al. 2014). Thus, the design and implementation of MGNREGA works must be followed up with efforts to sensitise beneficiaries towards the environmental aspects of these works.

Third, the lack of appropriate knowledge among practitioners is a major hurdle preventing MGNREGA from achieving its potential. Ponds, check dams, tanks, soak pits and other similar water conservation and harvesting structures are works, which are meant to lead to the green transformation of rural India. However, the study found that the engineering cadres, responsible for technical soundness of MGNREGA, are too few in number to be able to ensure that the works will serve their purpose. Panchayat-level functionaries, like the mates, rozgar sevaks and secretaries, have little knowledge about watershed development. Yet, they are the ones, who make crucial decisions, such as the location, direction, dimensions and design of works. Consequently, the rate of success of projects related to water conservation and harvesting is poor. In this context, the role of Cluster Facilitation Teams (CFTs) and Barefoot Engineers, who understand basic hydrogeology, would be extremely useful (MoRD 2013). In Andhra Pradesh, the Andhra Pradesh Farmer Management Systems is training local farmers in participatory hydrological monitoring, crop water budgeting and managing the available groundwater resources optimally (FAO and BIRDS 2010). Integrating these practices into planning and designing MGNREGA works would go a long way towards making it a truly 'green scheme'.

To conclude, this study provides an objective and comprehensive framework that can aid the planning and assessment of MGNREGA from an environmental perspective in order to improve the 'sustainability' and 'green impact' of MGNREGA jobs. Further research will be extremely useful in extending this analysis to other MGNREGA activities and other parts of the country.

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