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Mapping the impacts of solar water pumps on farmers' lives: Building a results framework for Components A and C of Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM)

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EXECUTIVE SUMMARY

HIGHLIGHTS

- In 2019, the Government of India launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM) Scheme to provide solar power to irrigation pump sets through individual solarization and feeder-level solarization.
- The plans for monitoring progress do not include tracking impacts on non-electricity-related parameters such as groundwater levels, crop patterns, CO_2 emissions, diesel consumption and costs, farmer income, and socio-economic benefits.
- This paper presents a suggested "results framework" to help implementing agencies monitor these indirect outcomes of the project and how they influence one another.
- This framework identifies the outcomes and indicators specifically applicable to the context of the intervention in order to investigate the interactions between water, food, and energy outcomes at various stages of implementation.
- If tested on the ground prior to large-scale adoption, this proposed monitoring framework can benefit farmers and enable multiple government departments to understand the metrics related to their work. It can be used to identify the overall developmental goals that can be achieved through the scheme.
- Suggestions for operationalizing monitoring and evaluation (M&E) systems are incorporated within the framework and its calculations, which can help users analyze the different kind of changes brought about by the schemes.

Context

The PM KUSUM Scheme, launched in July 2019, aims to solarize India's agricultural electricity use. In doing this, it takes on a major challenge facing India's electricity sector: reducing the subsidy burden on distribution companies (DISCOMs) due to the provision of free or subsidized electricity to agricultural consumers (among others).

The amount of electricity used in agriculture has increased about 48 times from 4,470 gigawatt-hours (GWh) in 1971 to 215,000 GWh in 2021 (CEIC n.d.). Electricity supplied to the agriculture sector has fueled the expansion of irrigation and agricultural production since the 1970s (Prayas [Energy Group] 2018). At the same time, the government has sought to balance the demand and supply of power used in agriculture; for instance, by urging farmers to improve energy efficiency and limit consumption when demand peaks (MoP 2015). Given the state of the finances of the electricity DISCOMs and the importance of conserving water resources, it is necessary to change the current models governing the provision and consumption of electricity in agriculture.

About this paper

Various organizations and agencies are tracking the overall progress of the PM KUSUM Scheme, but they do not investigate the impact it has had on beneficiaries. They do not seek perspectives from farmers to gauge whether PM KUSUM has affected changes in cropping patterns; that is, the type of crops that are traditionally grown, the levels of debt, or water usage. For example, several states are in the process of refreshing data based on the ongoing implementation of the PM KUSUM initiatives. According to the Indo-German Energy Forum (IGEF), specific states are furnishing information on various aspects of the implementation, including the quantity of solar pumps deployed, the type of pumps (AC/DC), subsidy allocation, and technical details such as water discharge and pump operation duration (IGEF n.d.). Historically, quantitative indicators such as the addition of installed solar capacity have been used to track the progress of solarization projects (van de Kerkhof et al. 2009), but to understand the holistic impact of PM KUSUM on farmers' lives, it is necessary to also understand the qualitative data and capture the socio-economic developmental changes within farmers' communities.

The PM KUSUM Scheme has three components: A, B, and C. This working paper examines Components A and C of the scheme, which include small solar-powered generators and on-grid solar pumps, respectively. It does not examine Component B, which includes off-grid solutions, because the paper's scope is restricted to grid-connected irrigation solutions within the PM KUSUM Scheme. Component A includes individual plants (up to 2 MW) that contribute 10,000 MW in aggregate, constituting a geographically dispersed set of decentralized ground-mounted renewable power plants connected to the main electricity grid. Component C of the scheme is aimed at solarizing 1.5 million agriculture pumps individually. These pumps currently draw electricity from the grid or through feeder-level solarization.

The research problem

Although quantitative indicators have been historically used to evaluate the success of solarization projects (van de Kerkhof et al. 2009), understanding the holistic impact of PM KUSUM requires examining qualitative data and understanding the developmental changes that occur around communities. Thus, indicators measuring these impacts need to be built into the results framework. Current evaluations reveal very little about the socio-economic components of livelihoods (beyond income), shifts in agricultural production, and so on. A wholly different approach may be needed to understand farmers' perspectives and experiences with PM KUSUM in particular and solarization schemes as a whole and how these might change over time. The results framework presented in this working paper will help implementing agencies track progress at various levels (implementation, project data analysis, outcome, and impact), which would include indirect changes. Implementing agencies can use this results framework to capture direct and indirect changes in their respective states and/or locations to holistically look at the various components of the PM KUSUM Scheme from feasibility to implementation to impact, and go beyond tracking just the addition of solar capacity.

Approach

To build this results framework, we used the water–energy–food (WEF) ecosystem nexus (UNECE 2022) to understand how the components—water, energy, and food—interact with each other during an intervention. This approach can help map the main themes and operational processes to ensure that M&E expands learnings and helps develop a holistic results framework. The WEF approach also enabled us to include the socio-economic components of income (Beaton et al. 2019) to align the results framework with the goals of the PM KUSUM Scheme. We used a literature review to identify the major themes and operational processes that would need to be included in the results framework.

We also incorporated a results-based management (RBM) system (FAO n.d.-a) for tracking the data needed for this evaluation. This will enable multiple stakeholders to ensure that results are measured systematically and are aligned with the outcomes and indicators defined in the results framework. Thus, using the RBM system can help PM KUSUM facilitate multi-stakeholder interaction toward data monitoring for various stakeholders and government departments. RBM will enable stakeholders to learn from the processes of M&E to move ahead as well as course-correct. This will also enable implementing agencies to understand key processes and suggest outcomes and indicators that can be tracked within Components A and C of the PM KUSUM Scheme.

This working paper also suggests that M&E operational systems can be included to implement the results framework on the ground, which will enable data capture for tracking outcomes. Apart from the final impact evaluation that various governmental schemes engage in, it is important to include evaluation cycles across the programmatic lifeline to understand the gaps in knowledge and mitigate the challenges that arise.

However, the proposed results framework has not been tested on the ground, and its benefits can only be confirmed by doing this. Therefore, the framework is designed to be iterative and dynamic, enabling the lessons learned from practical experience to be understood and facilitating the adjustments needed to gather evidence of changes. Agencies that can benefit from using this framework to understand the changes brought about by PM KUSUM should use it and share their firsthand experiences. This can enable this iterative framework to become robust over a period of time through multiple use cases.

Recommendations

This working paper utilizes field experiences to provide recommendations that governmental agencies can use to implement a results framework. We suggest that before the rollout of M&E, a thorough mapping of various departments that will take up the tasks and their responsibilities be carried out. Individuals who would be responsible for the management information system (MIS), data collection, and data systems should be trained on data maintenance and field protocol standardization. We recommend reviewing the M&E operations every month in the beginning and every three to six months in the later stages to understand the issues being faced on the ground from the perspective of the M&E plan.

The proposed framework and these recommendations can be used by other stakeholders to set up M&E systems for PM KUSUM. This will enable them to understand the scheme and the methodologies and indicators used to incorporate socio-economic impact.

INTRODUCTION

In July 2019, the Government of India, to solarize India's agricultural electricity use, launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM) Scheme. As of March 2020, India had electrified over 21.3 million pump sets (CEA 2020). All grid-supplied electricity to the agricultural sector is either free of charge or highly subsidized by state governments in accordance with their respective tariff policies, which entails major costs and revenue losses for electricity utilities. Some of the key objectives of the PM KUSUM Scheme are to

- increase decentralized solar power generation from the agricultural sector,
- reduce the dependence on diesel pump sets,
- reduce the agricultural greenhouse gas (GHG) footprint,
- provide an additional source of income to farmers, and
- reduce the burden of subsidized agricultural power consumption on electric utilities.

Therefore, as part of a national effort to reform the agricultural sector's energy use, the PM KUSUM Scheme seeks to accelerate the installation of decentralized solar photovoltaic (PV) and other renewable energy (RE) generation plants. PM KUSUM's target was to add 25,750 MW of solar capacity by 2022 through three specific intervention components with a total federal outlay of about INR 344.22 billion. This funding was meant to partly finance the capital expenditure[1] required to install grid-connected solar pump sets for agricultural purposes. Although it is a central scheme, launched by the Ministry of New and Renewable Energy (MNRE), it allocated a proportion of the 25,750 GW target to every state and its respective nodal agencies, and tasks them with delivering this assistance. For example, The Tamil Nadu Energy Development Agency (TEDA), in coordination with the department of finance and agriculture, oversees the implementation and manages the operations of the scheme in the southern state of Tamil Nadu.

In 2020, the goals were revised by the Government of India, and three components of the scheme—A, B, and C—were included: Component A aims to set up 10,000 MW of decentralized ground-mounted grid-connected solar power plants, with these plants being connected to pre-identified substations. Component B aims to install 2 million stand-alone solar-powered agriculture pumps in areas without grid penetration. Component C aims to solarize 1.5 million grid-connected agriculture pumps through two routes: individual pump solarization, in which farmers who have a preexisting pump set which is connected to the grid can solarize them; alternatively, states can opt to have separate feeders for agricultural connections and solarize those feeders. This working paper specifically looks at Components A and C of the scheme (MNRE 2020).

Up to October 2022, an aggregate solar capacity of 73.45 MW was installed under Component A "of the Scheme against [the] total allocation of 4,886 MW capacity and over 1.52 lakh [152 thousand] agriculture pumps have been reported solarized against the allocation of 33.5 lakh pumps under the Scheme" (PIB 2022). In December 2022, the Government of India extended the deadline for the achievement of the scheme's goals to March 31, 2026 (PIB 2022). In this paper, we do not examine Component B, which is solely an off-grid solution; we examine only Components A and C, which are grid-connected solutions. This is because the remit of the agencies we engaged with in different states was only Components A and C.

Current status of electricity and fuel consumption by the agricultural sector in India

The past decade has witnessed rising agricultural demand for electricity in India (IEA 2020). In 2020, the total estimated consumption by the agricultural sector reached about 228,172 GWh (CEIC n.d.). The amount of electricity used in agriculture has increased by about 48 times from 4,470 GWh in 1971 to 215,000 GWh in 2021 (CEIC n.d.).

The country's national electricity policy provides subsidies for agricultural consumers in an effort to ensure universal electricity access. At the national and subnational levels, governments have attempted to fiscally support electric utilities and put mechanisms in place to extend the reach of agricultural subsidies through schemes such as the Deen Dayal Upadhyaya Gram Jyoti Yojana[2] (IEA 2020). Since the 1970s, affordable electricity supplied to farmers has allowed them to irrigate their crops and improve production (Prayas [Energy Group] 2018). However, with growing agricultural production and irrigation needs, the demand for electricity supply and the associated subsidies to the sector has increased tremendously as well. This has led to an examination of possible efforts to reduce this subsidy bill and at the same time try to improve the sector's RE share.

Currently, it is estimated that introduction of PM KUSUM, especially Components A and C, would benefit various stakeholders (in terms of increasing farmers' income, minimizing farmers' bills, improving the energy efficiency of solar pumps, and decreasing the subsidy cost for electric utilities/governments) (Rahman et al. 2021). Additional income for farmers is achieved by introducing feed-in tariffs and the substitution of utility-supplied electricity by electricity generated from solar energy generators, which will in turn reduce the direct subsidies paid by state governments (Gambhir et al. 2021).

Current studies on solarization of agriculture

The MNRE attempts to track the overall progress of the PM KUSUM Scheme within the country through a national-level data platform (which also includes state- and district-wise data; [MNRE n.d.]). The platform studies the operational-level mapping of Components A, B, and C of the scheme in the country; however, it tends to overlook the beneficiaries (the farmers) and the effects the scheme may be having on them beyond limited income generation (from feeding back excess electricity to the grid). Moreover, the current evaluation of solarization schemes shows a limited understanding of how methodologies, frameworks, and impact should be viewed.

The current evaluations reveal very little about the socio-economic components of livelihoods (beyond income), shifts in agricultural production, and so on. Some studies suggest that solarization will impact the livelihoods of farmers by allowing the export of surplus electricity, and this is an example of a socio-economic component (Suman 2018). However, the challenge is scaling impact, reporting about impacts on a larger sample of farmers, and seeing peripheral effects on various components of livelihood such as a decrease in farm-level debts, an increase in household savings, a shift in migratory patterns, or shifts to other livelihoods (Rahman et al. 2021). Current studies do not examine questions such as how the farmers should be reached, other than by providing financial support to enable them to install solar pumps.

A wholly different approach may be needed to understand farmers' perspectives and experiences with PM KUSUM and how these change over time. Although quantitative indicators have historically been used to show success for solarization projects (van de Kerkhof et al. 2009), understanding the overall impact of PM KUSUM on farmers' lives requires examining qualitative data and investigating socio-economic changes and development in farming communities. Thus, indicators measuring impact need to be built into the results framework.

THE RESULTS FRAMEWORK

Methodology

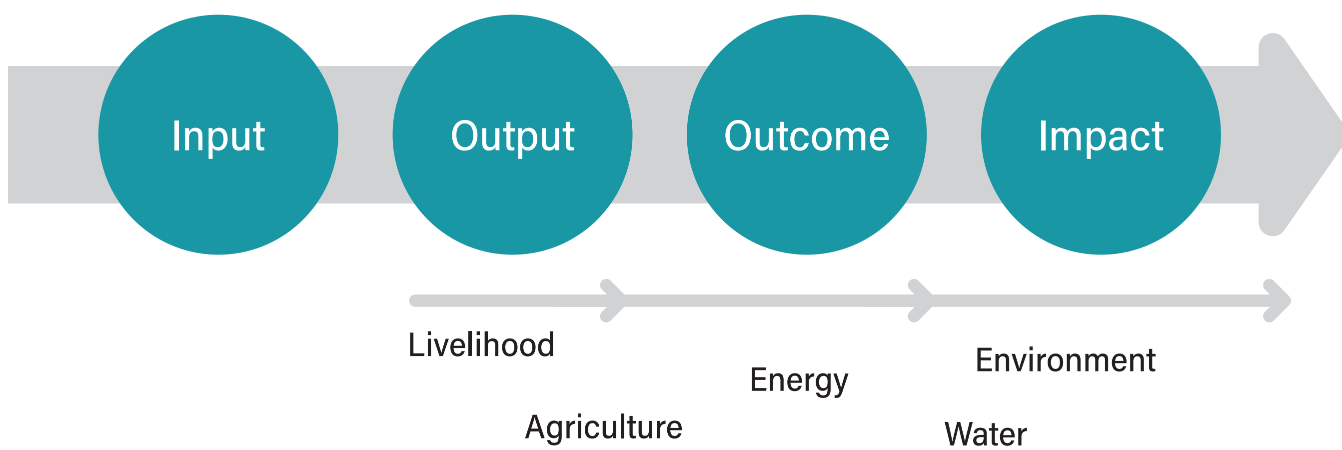
Developing a results framework requires both understanding the causal pathways (Figure 1) that lead to change and recognizing that change may not be linear. The framework maps the progression of the intervention and the inputs, taking into consideration the environment and other factors within which the outputs and the outcomes occur. The causal pathways reveal the ways in which the intervention will work on the ground. In addition, these pathways also point to the ways in which data can be collected and analyzed.

It is also important to understand the various topics that are not considered under M&E of current solarization and PM KUSUM Schemes across the country. A desk review of agricultural solar pumps helped us identify those topics and include the most important ones in the framework.

One of the first approaches for identifying themes for the framework was to understand the water-energy-food (WEF) ecosystem nexus (UNECE 2022). The framework was also vital for seeing how the WEF components exert interdependent effects on each other. Thus, when there is a change in one component, changes automatically occur in the other components. For example, if there are changes in the water availability for agricultural land due to the installation of solar agricultural pumps, the crop pattern adopted by the farmer may change. This aspect is useful for understanding development and its effect on a multi-theme subject such as solarization of agriculture. This approach helped map ways to build on the M&E of results within the PM KUSUM Schemes to gather more information on the range of ways in which the project influenced the lives of farmers on the ground. It laid the foundation for developing a holistic results framework. The WEF components helped understand the ways in which water, energy, and food are becoming scarce as populations increase and climate changes (FAO n.d.-b; UN Water n.d.).

The results framework was developed using two approaches to understand the impact of the PM KUSUM schemes. The first approach was the results-based approach, which helps understand and track the changes that may occur due to the introduction of the scheme. This approach helps one to understand the impact of the scheme in qualitative ways that can inform policy decisions on resources, stakeholders, and investments within similar schemes. The second approach is the reflexive approach, which will make the results framework dynamic. This approach helps gauge learning after the results framework is implemented. It also ensures that socio-economic indicators are included in similar projects and that they are able to capture the changes that result from the implementation of solarization programs (as explained in the following subsection titled "Incorporating varied themes and operational processes for a well-rounded impact").

Figure 1 | **Causal pathway of change**



Source: WRI authors.

In the section titled "Monitoring," we discuss a performance monitoring plan that has been developed by referring to the guide for developing a results framework authored by the United Nations Office for Disaster Risk Reduction. The performance monitoring plan in this working paper includes indicators and data collection methods, data type, reporting requirements (the time of data collection), the source of data collection, and the rationale for collecting data within a particular indicator.

To select indicators and outcomes, gap analysis has been used to identify gaps in the literature on irrigation solarization schemes. The analysis tried to identify outcomes that would help inform policy and build a holistic results framework. In the gap analysis of the literature on solarization schemes in the Global South, Africa and India were identified for the analysis. The literature review was also used to identify gaps in evidence within solarization programs. Further, the gap analysis was used to identify various themes; namely, energy, water, livelihood, agriculture, and environment.

The gap analysis will also analyze the solar irrigation literature to understand and include the operational processes—that is, the intervention—which would examine various activities under the PM KUSUM Scheme to understand the metrics one might need to implement the intervention on the ground.

The intervention and themes have been explained in detail in the section titled "Monitoring."

Implementing agencies can use this framework to holistically look at the various components of the PM KUSUM Scheme from feasibility to implementation to impact.

Incorporating varied themes and operational processes for a well-rounded impact

It was important to understand the scheme as well as its intended impacts. The first notification of the PM KUSUM Scheme (MNRE 2019) mentioned the need for a monitoring system for its projects. It called for installers to not only distribute solar pumps but also to install a remote monitoring system (which would provide real-time information on a dedicated Web portal) or run pumps solely on solar power. The monitoring system is used to observe the progress; that is, the total number of pumps installed and the solar capacity across all the components of PM KUSUM.

Recent updates indicate that the German Agency for International Cooperation (GIZ) India's Indo-German Energy Programme (IGEN), through its Promotion of Solar Water Pumps module, is supporting the MNRE in developing and enhancing the current digital portal. Some states are currently updating data from work being done on the ground for PM KUSUM. A brochure published by The Power Sector Reforms (PSR) Programme, a Technical Assistance program launched by the Ministry of Power (MoP) and the UK Government, indicates that they are developing the Solar Energy Data Management (SEDM) portal for the MNRE and the states of Haryana and Gujarat, where the following parameters are being captured: the solar capacity added, annual CO_2 reduction, annual reduction in diesel consumption and costs, number of workers trained, and total number of beneficiaries (Nair 2021).

In addition, states have been given the option to add more parameters on state portals while developing them, depending on the state's realities and contexts. Even though the data sets may include many indicators that will help the government assess the PM KUSUM program holistically, two problems could arise: one, all states may not be able to update and include the data parameters for the PM KUSUM components due to operational, budgetary, and personnel challenges; and two, currently, most of the data indicators are not accessible to the public, which may result in issues of data availability (GIZ 2023).

Although these are important parts of any scheme, they are, in effect, post-implementation additions. It is essential to include mechanisms within the monitoring of implementation even before the rollout, which can be useful to derive lessons that the government and the institutions that are part of the scheme can use moving forward. Moreover, evaluation processes should be an integral part of the scheme; they should be conducted not just when the scheme is concluded but at regular intervals to take stock of incremental outcomes, which can lead to large-scale impact.

We intend to test this framework and M&E process in Tamil Nadu, because it is the state where we are engaged with PM KUSUM stakeholders and have been focusing on the energy transition since 2019. It should also be noted that the framework is developed in such a way that other states can also incorporate it within the state-level PM KUSUM implementation to understand the causal effects in their respective states.

Importance of setting up MIS and data systems from the beginning of the implementation phase

A scheme such as PM KUSUM will produce a variety of data including information such as farmers' access to the scheme and the barriers they are facing, their electricity bills, how the solar pumps are working, and the effects they have had on their land and water table. It is important to understand that it is not one management information system (MIS) that would be a part of the M&E process, but multiple MIS systems, placed in different agencies and ministries (depending on the role they play within the scheme) interacting together as a whole. The MIS in different agencies should be built using the expertise of a particular agency and its role within PM KUSUM. The main different types of MIS could be implementation, project learnings, operational MIS (for vendors and service agencies), and so on. The information system would need to be dynamic to capture all the information that all stakeholders need in order to build and assess the results framework periodically.

Thus, for PM KUSUM, the following systems could be set up by agencies and stakeholders to generate M&E data:

- **Data systems and data collection.** This is the system used to collect data on the initial uptake of the PM KUSUM Scheme, mapping the number of farmers who convert from grid-fed pump sets to grid-connected solar pump sets. It would record baseline information; for instance, the tariff that farmers pay for electric pump sets powered by the grid and what they pay for diesel during power cuts.
- **Operational management system.** The system would help implementing agencies (in this case, TEDA) to ensure initial monitoring during the implementation of the PM KUSUM Scheme.
- **Scheme management.** This would ensure the mapping of farmers who have enrolled in the scheme and help agencies such as Tamil Nadu Generation and Distribution Company (TANGEDCO) track the extent to which the solarized pumps are operational during the daytime and how much incentive (payment) each farmer would earn from feeding energy back into the grid.

Table 1 shows the various implementing agencies (TNERC 2021) and the ways in which they can use MIS systems to track the various indicators and data within the M&E process before and after the scheme is implemented in the state. The MIS would also help identify successes and learnings through the sets of indicators in the results framework. The current literature suggests that it is important to track varied levels of M&E processes, which include coordination across the various agencies and institutions involved in implementing PM KUSUM at the state level (Goel et al. 2021).

Table 1 | **Suggested MIS system usage**

TYPES OF MIS	STAKEHOLDERS	DATA SETS INVOLVED
Data systems and data collection	Farmers' association, TEDA, farmers cooperatives, panchayats, FPOs, Department of Rural Development, water user associations (WUAs)	Additional income received by farmers, other issues recorded (by agencies) related to the scheme and its uptake, water usage on agriculture, water bills generated (if any), expenditure pattern of farmers due to less dependence on fossil fuel
Operational management system	TEDA, renewable energy development agencies	Current grid-connected pumps, solar pump remote monitoring systems
Scheme management	TANGEDCO	Subscription of PM KUSUM Scheme, payment of incentives to participants, solar pump remote monitoring systems, and operation and management of solar installations

Notes: FPOs = farmer producer organizations; TANGEDCO = Tamil Nadu Generation and Distribution Corporation Limited; TEDA = Tamil Nadu Energy Development Agency.
Source: WRI authors.

These systems need to address operational project management needs and be available across agencies to prevent duplication of interventions/data collection, and so on. It would also be important to embed MIS personnel as part of this system to help each implementing agency maintain these data systems for the duration of the scheme and possibly beyond. MIS personnel would be able to support various components of capacity building that agencies might need to ensure the quality of data management. Apart from personnel, all stakeholders should assess other types of resources they would need to start setting up systems (financial, technological, etc.) (FAO n.d.-a).

MONITORING

Introduction: Monitoring indicators for PM KUSUM

Before identifying the indicators, it was important to evaluate the various monitoring models that can be applied to the solarization of agriculture. The Global Change Assessment Model (GCAM) was the most important component for understanding the various intersections of themes and building indicators (Hejazi et al. 2013). The GCAM is a tool built to explore the interactions between five themes: climate, economy, agriculture, land use, and energy systems.

The framework in this paper is developed by incorporating some components used by the Global Change Assessment Model (GCAM), replicating it in the context of the PM KUSUM Scheme, and supporting the process of building a results framework covering energy, water, livelihood, agriculture, and the environment. Unlike the GCAM, this framework does not help implementing agencies perform modeling work across the themes. The framework provides a set of indicators that various implementing agencies and governments can use for tracking results within the PM KUSUM Scheme.

Selection of indicators (based on Components A and C of the PM KUSUM Scheme)

Operational processes and interventions

The framework first suggests the initial operational indicators that various agencies can use as a starting point to track changes. Further, the indicators would be tested by the agencies on the ground when they implement projects. The testing would include activities such as stakeholder analysis, power mapping, and perception surveys.

These activities will allow agencies to monitor processes, allowing learnings to be derived from shorter process evaluations to see how the scheme is affecting the beneficiaries. This component would help implementing agencies align their MIS systems with various outcomes and monitor them. Interventions focus only on the initial stages of the implementation and help agencies set up operational systems they can learn from (Table 4).

Thematic areas

A desk review of the literature on solarization of agriculture, especially in the Indian context, helped formulate outcomes and indicators across themes. The themes support the development of the results framework and are geared toward developing a comprehensive understanding of the overall changes that the PM KUSUM Scheme seeks to bring about.

ENERGY

Without electricity, it can be difficult to irrigate farmlands. Pumps powered by grid-connected solar plants can provide more hours of operations for the farmer than grid-powered pumps, especially considering the rationing of power supply in different states (Pasupalati et al. 2022). A steady supply of solar energy can also alleviate the need to depend on backup generators that burn diesel or other fossil fuels. This can allow farmers to take control of the duration and amount of the water supply needed for irrigation, reduce their expenditure on fuel, and reduce their GHG emissions (Gupta 2019) (Table 5).

WATER

Agriculture consumes about 90 percent of India's groundwater (World Bank 2020). If this usage is not monitored carefully, the solar pumps installed under the PM KUSUM Scheme may lead to overextraction of water in a few regions (Siepman n.d.). However, the extent of this risk has not been quantified.

The Government of India has recognized the importance of monitoring the usage of resources such as water to prevent overexploitation and informing communities about unsustainable practices (NITI Aayog and World Bank 2019) (Table 6).

LIVELIHOOD

Solar pumps would improve farm livelihoods by reducing the dependence on diesel generators (Prayas [Energy Group] 2018), thus reducing the expenditure on fuel. Component C, as mentioned in the scheme, would also enable farmers to earn extra income by feeding extra solar energy back into the grid at a price set by the state agencies (Table 7).

AGRICULTURE

Better access to irrigation and water can raise agricultural production and yields (KPMG 2014). Beneficiaries of the scheme enjoyed increased cropping intensity,[3] and farmers covered by the scheme chose crops that need more irrigation in many states where the scheme has been implemented (Kalamkar et al. 2019). However, overuse of water can still be an important issue. It is important to understand and monitor water usage and suggest how it can be mitigated within particular regions through the results framework (Table 8).

ENVIRONMENT

Burning less diesel or reducing consumption from the grid would cut GHG emissions, provide reliable access to clean energy, and encourage shifts toward non-fossil-fuel-based systems (Table 9).

Selection of outcomes: Designing the results framework

The outcomes are categorized into themes, which have been described in the previous section. To maintain homogeneity among all stakeholders, the outcomes are based on standardized methods of data collection and the establishment of uniform interpretations of the changes that will occur. These outcomes can be used by implementing agencies in various ways, particularly in MIS system building, for monitoring the scheme. It should also be noted that any outcome/indicator that is active at a given period of time (0–11 months, 1–2 years, 3 years and more) would continue to be tracked henceforth.

Table 2 explains the various components of the indicators so that users can make full use of the results framework. The "Uses by agencies" column in the table is broken down into two elements: one, indicative, which means that agencies should ideally follow the same/similar methods to track the changes; two; suggestive, which are suggestions to agencies, which can follow the same format or draw from their experiences to modify the suggested methods.

Time frame and results chain

Table 3 shows a log that references aspects from the results chain against timelines so that users can understand the documented changes. Also see Figure 2.

Table 2 | **Components of the results framework**

STANDARDIZATION ELEMENTS	EXPLANATION	USES BY AGENCIES
Metric	Values/units that can be used to present the data	Indicative
Data sources	Institutions/departments that may have the data	Suggestive
Data type	The type of data that should be collected	Indicative
Time of data recording	Time of data recording during the cycle of the scheme/implementation	Suggestive
Data recording	The cycle in which the data should be recorded for particular indicators	Indicative
Type of metric	The type of M&E process involved	Indicative

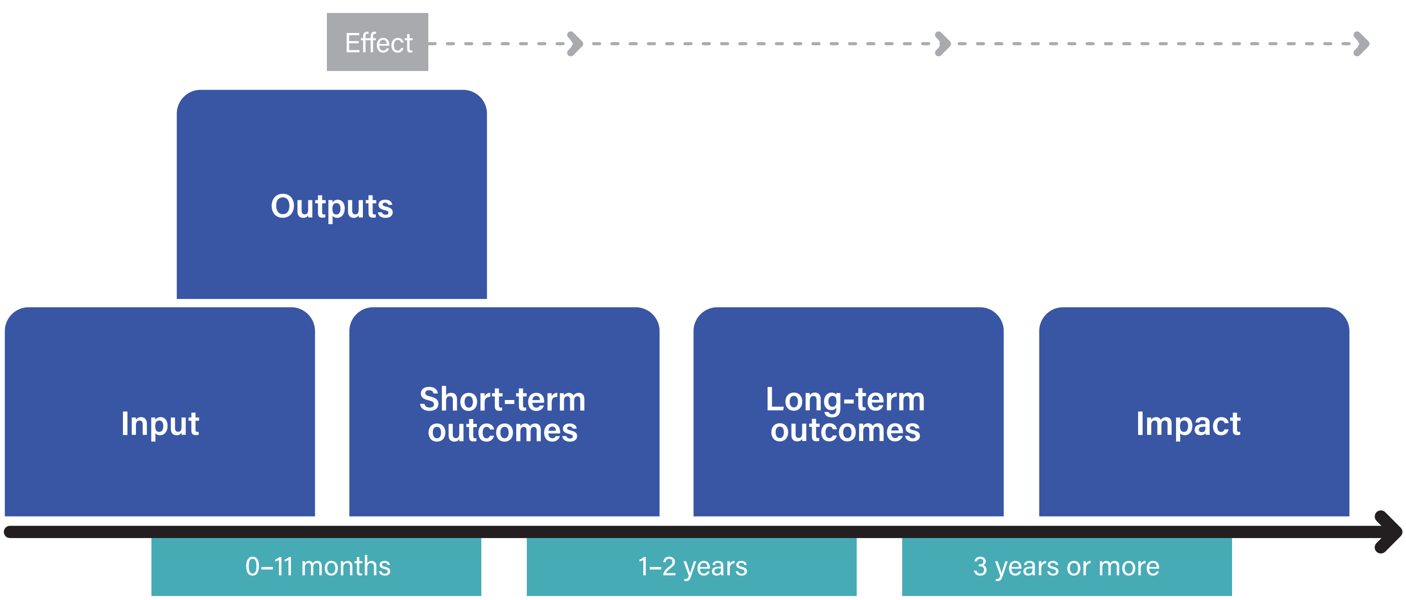
Notes: M&E = monitoring and evaluation.
Source: WRI authors.

Table 3 | **Timeline references of result chain**

TIMELINE	RESULTS CHAIN	EXPLANATION
0–11 months	Outputs	These changes occur directly in relation to the input of the project and are controlled by the input of the project or program (e.g., the installed capacity of SPV pump sets, types of farms that have applied for the scheme [based on their size])
	Short-term outcomes	These are immediate results achieved after the changes are observed in the outputs; here, all stakeholders can more easily track the attributions of changes (e.g., the total energy exported from agricultural SPV systems: the excess energy generated from such systems gives farmers a source of income)
1–2 years	Long-term outcomes	These results are seen after a period of implementation. These changes are more complex and not exclusively quantitative in nature. They may occur a result of combined changes beyond just the intervention. For example, the number of hours/days of paid labor worked on the fields (before installation/after installation), average monthly income from crop production per household (which increases annually)
3 years or more	Impact	These changes will illustrate the long-term effects on beneficiaries and their communities. They would also include changes affecting stakeholders who might not be direct beneficiaries of the PM KUSUM Scheme (e.g., families of farmers, households). These changes are the most complex ones; often, evaluative methods are needed to capture them (e.g., changes in attitudes toward solar, the ability of farmers to repay their farm-based debts [e.g., before PM KUSUM and NABARD loans])

Notes: NABARD = National Bank for Agriculture and Rural Development; PM KUSUM = Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan; SPV = solar photovoltaic.
Source: WRI authors.

Figure 2 | **Time frame and results chain**



Source: WRI authors.

Interventions

Table 4 illustrates the operational indicators.

Table 4 | **Interventions/operational processes**

	OUTPUT INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING (IF ANY)	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)	RATIONALE
Intervention	Number of farmers applying for the scheme (gender, caste, and age (G/C/A) of the applying farmers)	X	TEDA	Quantitative	X	Pre-installation	Monitoring	Will help understand the reach of the scheme. Will also enable any group of farmers that is not enrolled in the scheme to be contacted.
	Number of successful (approved) applications (G/C/A)	X	TEDA	Quantitative	X	Pre-installation	Monitoring	Will help understand if bureaucratic processes are creating barriers for farmers.
	Number of unsuccessful applications (G/C/A)	X	TEDA	Quantitative	X	Pre-installation	Monitoring	Will help understand the barriers faced by farmers, why applications are unsuccessful, and how this can be addressed.
	Types of farms that have applied for the scheme (based on their size)	Disaggregation of the types of farms in Tamil Nadu (Marginal<1 ha; Small (1–2 ha); Medium (2–10 ha); and Big (>10 ha)	X	Quantitative	X	Pre-installation	Monitoring	Will give insight into the demography of beneficiaries.
	Capacity of pump installed	In HP	TEDA	Quantitative	X	Post-installation	Monitoring	Operational: This can be used as a proxy indicator for groundwater extraction.
	Installed capacity of SPV system	MW (for aggregated data)/kW (individual data)	TEDA	Quantitative	X	Post-installation	Monitoring	Operational: This can help understand the extent of oversizing of solar. It can also be used as a proxy indicator for how much the farmer earns by injecting power into the grid.
	Issues faced by beneficiaries a. Number of farmers who have registered complaints about the pumps b. Type of complaint	Remote monitoring systems (RMSs), if available through metering; meter readings of farmers	TEDA/ third-party install-ation of pumps under PM KUSUM	Quantitative	Monthly	Post-installation	Monitoring	Will help identify the initial and subsequent issues farmers face with pump sets. It would also help set up better O&M mechanisms for the sustainability of these pumps in the future.

Table 4 | **Interventions/operational processes (cont'd)**

	OUTPUT INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING (IF ANY)	DATA RECORDING	TYPER OF METRIC (MONITORING/ EVALUATIVE)	RATIONALE
Intervention	Number of farms where pumps have started recording renewable energy (RE) consumption (metering)	RMSs, if available through metering; meter readings of farmers	TEDA/ third-party installation of pumps under PM KUSUM	Quantitative	Monthly	Post-installation	Monitoring	Will help set up better O&M mechanisms for the sustainability of these pumps in the future.
	Number of resolved complaints	X	TEDA/ third-party installation of pumps under PM KUSUM	Quantitative	Monthly	Post-installation	Monitoring	Will help identify the various ways in which complaints have been addressed and the learnings can be taken forward.

Notes: ha = hectares; HP = horsepower; PM KUSUM = Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan; kW = kilowatt; MW = megawatt; O&M = operations and maintenance; TEDA = Tamil Nadu Energy Development Agency; X = to be decided during implementation.

Source: WRI authors.

Energy

Table 5 illustrates the indicators related to energy.

Table 5 | **Energy Indicators**

TIMELINE	OUTCOME	INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
0–11 months	Export of direct on-farm renewable energy (RE) increases	a. Total energy produced b. Total energy exported from agricultural SPV systems to the grid	kWh (should also include time stamps from the remote monitoring system [RMS])	TEDA/ TANGEDCO	Quantitative	Monthly	Post-installation	Monitoring
	Grid energy consumed by farmers decreases	a. Energy drawn from SPV and energy drawn from the grid b. Consumption of agricultural pump energy	kWh	TEDA/ TANGEDCO	Quantitative	Monthly	Post-installation	Monitoring
	Farmers upgrade to energy-efficient pump sets	Percentage of farmers with energy-efficient pump sets	Percent = Total number of farmers with energy-efficient pump sets/Total number of farmers with pump sets	TANGEDCO	Quantitative	X	Pre-installation	Monitoring

Table 5 | **Energy Indicators (Cont'd)**

TIMELINE	OUTCOME	INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
0–11 months	Attitudes toward RE source changes	Change in attitudes toward solar	This will be a perception qualitative survey to understand the changes (if any) brought about by the introduction of a RE-powered pump	Baselining through farmer coopera-tion, unions, etc.	Qualitative	Baseline	Pre-installation	Evaluative (mapping exercise)
1–2 years	Attitudes toward RE source changes	Change in attitudes toward solar	Qualitative: Based on response from the beneficiaries	X	Qualitative	Annual	Mapping of induced behavior due to installation of SPV	Evaluative
3 years and more	Attitudes toward RE source	Change in attitudes toward solar	Mapping of demand of RE sources by farmers from midline data	X	Qualitative	One time/ map it against similar indicators in previous years	Third party	Evaluative

Notes: kWh = kilowatt-hour; SPV = solar photovoltaic; TANGEDCO = Tamil Nadu Generation and Distribution Corporation Limited; TEDA = Tamil Nadu Energy Development Agency; X = to be decided during implementation.
Source: WRI authors.

Water

Table 6 illustrates the indicators related to water.

Table 6 | **Water indicators**

TIMELINE	OUTCOME	OUTPUT INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
0–11 months	Application of irrigation technology changes	A reliable source of water on the farm (any other sources of water used on the farm by the farmers/decreasing dependence on freshwater resources)	Current irrigation technology vs. technology used every year (comparative data)	PMKSY website (PMKSY n.d.)	Quantitative	Annually (to see shifts in patterns due to PM KUSUM)	Post-installation	Monitoring
	Pressure on freshwater resources does not increase		Mapping of dependence with various water resources available before and after the program was implemented	Farmers' associ-ation/ water user associa-tions (WUAs)	Qualitative/ quantitative	Bi-annually	Pre- and post-installation	Monitoring

Notes: PMKSY = Pradhan Mantri Krishi Sinchayee Yojana.
Source: WRI authors.

Livelihood

Table 7 illustrates the indicators related to livelihood.

Table 7 | **Livelihood indicators**

TIMELINE	OUTCOMES	OUTPUT INDICATOR	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
0–11 months	Average monthly income increases	The excess energy generated from SPV is a source of income for farmers	Government order (MNRE 2023)	TEDA	Monthly	Quantitative	Post-installation	Monitoring
1–2 years	Average monthly income from crop production per agricultural household increases	Average monthly income from crop production per household increases annually	INR/month	Per house-hold, sampled method	Annual	Quantitative	Post-installation	Monitoring
	Pressure to find alternative means of livelihood during the non-irrigation season decreases	Farmers can sell the electricity not consumed during the off season (especially if there is a cap on feeding electricity back to the grid)	Per unit/INR	TEDA	Quarterly	Quantitative	Post-installation	Monitoring
3 years and more	Farm-level debts ease	Farmers are able to pay back their farm-based debts (e.g., PM KUSUM and NABARD loans)	PM KUSUM and NABARD loans	Farmers' associa-tion, NABARD	Annual	Quantitative/ qualitative	Post-installation	Monitoring/ evaluative

Notes: INR = Indian Rupee; NABARD = National Bank for Agriculture and Rural Development; PM KUSUM = Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan; TEDA = Tamil Nadu Energy Development Agency.
Source: WRI authors.

Agriculture

Table 8 illustrates the indicators related to agriculture.

Table 8 | **Agricultural indicators**

TIMELINE	OUTCOMES	OUTPUT INDICATORS	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
1–2 years	Change in crop intensity	a. Number and type of crops introduced b. Number of crops replaced by new crops	Identifying records (agricultural output per farm)	At the level of cooper-atives (APMC)	Quantitative	Annual	Farmers association	Monitoring/ evaluative
	Increase in crop yield	Amount of crops produced by farmers in the PM KUSUM Scheme	Identifying records (agricultural output per farm)	At the level of cooper-atives (APMC)	Quantitative	Annual	Farmers association	Monitoring/ evaluative

Notes: APMC = Agricultural Produce & Livestock Market Committee; PM KUSUM = Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan.
Source: WRI authors.

Environment

Table 9 illustrates the indicators related to the environment.

Table 9 | **Environmental indicators**

TIMELINE	OUTCOMES	OUTPUT INDICATORS	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
0–11 months	Decreased reliance on diesel generator sets/other sources of electricity for irrigation	a. Number of hours farmers use solar energy b. Number of hours farmers use the grid connection c. Number of hours farmers use diesel generator sets	Identifying records (agricultural output per farm)	At the level of cooper-atives (APMC)	Quantitative	Annual	Farmers association	Monitoring/ evaluative
	Decrease in GHG emissions in irrigation	Decrease in CO_2 emissions due to uptake of RE installations and decrease in the usage of diesel generators	([CO_2 emissions from electric water pumps] × number of solar pumps installed) – ([CO_2 emissions from diesel generator and grid] × [the number of hours used])	Respec-tive coord-inating agency	Quantitative	Annually	Post-installation	Monitoring

Table 9 | **Environmental indicators (Cont'd)**

TIMELINE	OUTCOMES	OUTPUT INDICATORS	METRIC	DATA SOURCE (IF ANY)	DATA TYPE	TIME OF DATA RECORDING	DATA RECORDING	TYPE OF METRIC (MONITORING/ EVALUATIVE)
1–2 years	Decrease in GHG emissions	Decrease in CO_2 emissions due to increase in solarization	(25,570 MW × 0.2 × 8,760)[a] × 0.715[b]	X	Quantitative	Annually	Post-installation	Monitoring/ evaluative
3 years and more	Decreased reliance on diesel generator sets/other sources of electricity for irrigation	a. Number of hours farmers use solar energy b. Number of hours farmers use the grid connection c. Number of hours farmers use diesel generator sets	Decreased reliance= a– (b + c)	Third party/ TEDA	Quanti-tative/ qualitative	Annually/ one-time evaluative study	Post-installation	Monitoring/ evaluative

Notes: a. This figure (8,760) is the number of units produced by solarization using 25,750 MW of solar capacity by 2022 standards. b. The carbon emission factor of grid electricity (including RE) (tCo2/MWh) (MoP 2022). CO_2 = carbon dioxide; GHG = greenhouse gas; MW = Megawatt; TEDA = Tamil Nadu Energy Development Agency; X = to be decided during implementation.
Source: WRI authors.

Designing tools for data collection: Challenges and learnings

One of the major challenges in data collection is to create tools and formats for capturing data. For large projects, the design should not only be standardized, but it should also be able to validate data across all the locations where it is being implemented (Bullen 2014). A major challenge is to create the tools and formats needed to capture data. Large projects should be designed not just to standardize data but also to validate data across all implementation location.

Building tools according to outcomes: When building tools, it is important to keep the outcomes in mind. If this is done, the result will be a well-rounded tool that can help track/capture data, which is our goal for the results framework. A structured tool that is aligned with the outcomes would also prevent errors during data collection and analysis.

Decision-making, tool building, and the MIS: A project that involves multiple stakeholders may lead to duplication of data systems. However, it would be necessary for all the MIS systems to be available to all the concerned implementing agencies so that they can make an informed decision about the need to collect data. The MIS system should ideally be able to accommodate multiple stakeholders.

Testing the tools: Piloting the tools, especially the ones used when evaluating the project at various points in time, is important. Testing tools on the ground is important. Research tools may seem to work well when comparing them with outcomes in a controlled laboratory environment, but implementing the tools on the ground may produce different results. Thus, testing the tools before implementation will ensure that they are able to capture all the targeted data.

Establishing the baseline: Learnings from MIS and data systems

Operational outcomes can be one of the first types of data collected, which will help implementing agencies create a baseline. Although operational data can be useful in setting up this baseline, it is essential to also acknowledge its limitations. The framework in its current form captures only quantitative operational data. If implementing agencies think qualitative data such as ownership of solar pumps, perceptions about solarization, and the current status of livelihood/income of farmers need to be captured, the stakeholders would have to design the required tools and protocols.

This decision depends on the needs of stakeholders and their commitment to exploring evidence on community-centric impact.

REPORTING PROGRESS: ANALYSIS OF BASELINE AND MIS DATA SETS

The RBM system embedded within this process will help agencies measure evidence for the next steps within their systems of governance (Kusek and Rist 2004). The establishment of an MIS and setting up a baseline will ensure that the first steps are well grounded. Implementing agencies also need to understand that analysis of data cannot be solely dependent on one MIS or a few indicators; the analysis has to be done through cross-learning from the various available data sets and MIS systems (Lai et al. 2012).

It should also be noted that progress reports should include people, the agencies involved, the type of data, and the type of report to ensure the regularity and maintenance of MIS data and systems (Global Donor Platform for Rural Development 2008). This will ensure accountability across all stakeholders and thus help maintain updated MIS systems.

TYPES OF EVALUATION

Learnings from process evaluation of PM KUSUM

Process evaluation of PM KUSUM should be conducted by the agencies themselves. Because the evaluation will be used to learn from the initial implementation, it is best conducted within the first year of introduction of the scheme. To ensure that the initial implementation of the scheme is sound, these evaluations should include MIS system managers, project managers, and leads, as well as inputs and outputs from the logic chain.[4] Further, these evaluations would help set up effective operational systems maintained by agencies. These evaluations can also include the suggestions of a third-party agency that can recommend the best ways to advance the project after each evaluation cycle. These evaluation cycles can be set up by the implementing agencies at regular intervals depending on their needs.

Designing outcome evaluations (midterm review)

Outcome evaluations assess whether the midterm goals of a program are being achieved. These goals mostly pertain to the beneficiaries of the program, and progress is evaluated from the outcomes identified in the results framework (Salabarría-Peña et al. 2007). An outcome evaluation would also be able to determine the impact of the program on the beneficiaries and assess those aspects of its contribution that are not necessarily under the control of the program itself (FAO n.d.-a). This kind of evaluation is used as an input to decision-making about program effectiveness (Boothroyd 2018) and learning from activities that do not work efficiently toward intended results/outcomes.

Outcome evaluation can be undertaken by involving a third party. Delegating these evaluations to a third party can be the best way to prevent bias and gauge the realities of the field from multiple perspectives.

Evaluating long-term impact

Long-term impact evaluation helps assess the overall effect of the scheme on farmers and their environments. This would also include any behavioral and socio-economic changes brought about by the program. This kind of evaluation will also enable policymakers to go beyond quantitative physical parameters, which are still the main components used to evaluate the success of governmental programs and schemes. This evaluation process supports evidence-based policy formation and provides a comprehensive analysis of a large-scale process (Gertler et al. 2016). Long-term evaluations are best designed and operationalized by external evaluators. Just as with outcome evaluation, external evaluation would help prevent bias and enable the scheme to be analyzed from multiple perspectives of impact.

FINDINGS AND RECOMMENDATIONS

At the time of this writing, the rollout of Components A and C is yet to occur in Tamil Nadu. For Component C, a Tamil Nadu Electricity Regulatory Commission order has been issued, but the subsequent follow-up and call for farmers to participate in this scheme is awaited (Energy Department, Government of Tamil Nadu 2020). Similarly, for Component A, TANGEDCO has issued an order but, again, follow-up action is awaited.

The following points can help prepare for the full implementation. This working paper can help various departments formulate the M&E plan in advance.

Current status of M&E systems

- Current M&E systems have been able to enable accessibility by digitalizing systems to a great extent. However, these systems are at the moment helpful only in the phase of monitoring quantitative data. They do not take account of how narratives and lived experiences affect the beneficiaries.
- Moreover, M&E systems, especially in technology-input-heavy programs, need to be designed with the understanding that technological inputs can create a ripple effect across socio-economic and developmental indicators.

Identified gaps

- A policy meant for a particular group or community should always consider its possible impacts 3–5 years after the policy is rolled out. This time frame will help the challenges faced and successes achieved to inform the policies. Moreover, from the perspective of M&E, this time frame will enable the policy's outcomes and short-term impact to be captured rather than just its outputs. The policies would thus be able to create evidence of its successes not just in the short term but also in the long term, creating perspectives and knowledge about policy sustainability and scale-up.
- The government will also be able to report more fully on developmental indicators by assessing these outcomes through their programs. It will be able to build success stories of developmental intervention.
- In the initial stage of any policy, outputs are usually successfully mapped, but the rollout and operationalization should also be captured. The input stage of M&E can be crucial, especially in the first phase of rollouts. Implementing agencies can learn about the gaps and challenges and address them during the next phase or scale-up of the rollout. Moreover, by tracking inputs, the barriers to program access that beneficiaries face can be identified. This enables the operational process to be adjusted to eliminate these barriers.

Proposed M&E

- Any rollout of M&E should start with initial convenings of the various departments that will take up the tasks. This will clarify the responsibilities for M&E activities and ensure that the rollout of the scheme can be replicated at various subnational levels.
- Individuals who will be involved in management of MIS, data collection, and data systems should be trained to maintain data and field protocol standardization. This training should also include creating capacities within agencies to understand the different components of M&E and to implement any plans the government may have.
- It can also be helpful for agencies/departments implementing M&E to review the M&E operations every month in the beginning and every 3–6 months in the later stages to understand the issues being faced on the ground from the perspective of the M&E plan.

Current limitations

- One of the biggest challenges is coordination among the agencies and departments.
- The indicators and framework suggested above are not necessarily intended to be implemented by a single agency. As mentioned earlier, agencies can choose the indicators best suited for them and test and validate the results for a particular set of indicators depending on the role they play in the PM KUSUM Scheme. In addition, any M&E learning that arises due to other organizations, agencies, and research projects should always be applied when advancing processes.
- Having point persons in each agency may help coordinate the scheme's M&E activities in a more streamlined fashion. Moreover, having a person who can lead M&E activities across the agencies would help in understanding the bigger picture of the PM KUSUM Scheme and its various activities.
- The PM KUSUM Scheme has been able to set up robust monitoring systems. However, to understand how the scheme will affect farmers' income and other peripheral changes, it would need to incorporate various types of methodologies of evaluation within its M&E plans, such as midterm reviews and impact evaluation.

ABBREVIATIONS

APMC Agricultural Produce & Livestock Market Committee

DISCOMs distribution companies

G/C/A Gender, Caste, Age

GCAM Global Change Assessment Model

GHG greenhouse gas

GIZ German Agency for International Cooperation

GWh gigawatt-hours

IGEF Indo-German Energy Forum

IGEN Indo-German Energy Programme

M&E monitoring and evaluation

MIS management information system

MNRE Ministry of New and Renewable Energy

MoP Ministry of Power

PM KUSUM Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan

PSR The Power Sector Reforms

PV photovoltaic

RBM results-based management

RE renewable energy

RMS Remote Monitoring System

SEDM Solar Energy Data Management

SPV solar photovoltaic

TANGEDCO Tamil Nadu Generation and Distribution Company

TEDA The Tamil Nadu Energy Development Agency

WEF water–energy–food

WUA water user associations

ENDNOTES

1. Capital investment within the scheme has three components: one, "[the] feeder can be installed through [the] DISCOM's own expenditure"; two, "the annual subsidy being presently provided for supply of electricity to agriculture pumps by [the] State Government can be used to repay the loan in five to six years, after which solar power will be available free of cost and outflow from [the] State Government's exchequer on account of electricity subsidy for agriculture will come to an end"; three, "for installation of feeder level solar power plant, CFA of 30% (50% in [the] case of North Eastern (NE) States, hilly states/Union Territories (UTs) and Island UTs) will be provided for CAPEX/RESCO Mode by [the] Central Government" (MoP 2022).
2. The Deen Dayal Upadhyaya Gram Jyoti Yojana is a scheme introduced by the Government of India to facilitate continuous supply of electricity to rural India.
3. Cropping intensity is the ratio of the gross area sown to the net area sown.
4. The logic chain is a virtual representation that shows how an intervention or scheme is supposed to work.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.