IBM – IORF

SUSTAINABILITY PROJECT

Adoption of a Cluster of Villages for Agricultural Sustainability and Food Security through Clean Food Program

PROJECT SITE :
District- Mandya , State- Karnataka, India

PHASE- 2 PROJECT

MILESTONES

Summary of Achievements

IBM **Corporate Social Responsibility**

PROJECT SITE :

District- Mandya , **State-** Karnataka, India

MILESTONES

1. **Demonstration of Large Scale 'Waste to Wealth' Program through bioconversion of Coir Pith and Press Mud- High GHG Emitters and highly soil and water polluting materials; utilizing Novcom Composting Technology.**
2. **Demonstration of Sustainable Management Practice in Sugarcane Cultivation**
3. **Demonstration of Sustainable Management Practice in Vegetable Cultivation (Model Plots).**
4. **Development of Clean Food 'NET ZERO' encompassing THREE LAYERS OF SAFETY- Safe for Human Health, Safe for Soil Life & Safe for the Environment.**
5. **Safety Authentication of the Clean Food 'NET ZERO' using the Food Safety Assessment Tool.**
6. **Soil Quality Appraisal of the Project Area & Soil Health Card for the farmers**
7. **Development 'Reclamation Model' for converting Degraded Land to Agriculturally Suitable Land through adoption of IRF Technology.**
8. **Developing a GHG Mitigation Model with added Social and Environmental Impact and a potential for mitigating 30 – 40 lakh metric ton CO_2 equivalent/ year, in India.**
9. **Development of Resource Maps of the Project Area**

IBM Corporate Social Responsibility

MILESTONE 1

New 100 hectare Project- Mandya, Karnataka

Demonstration of Large Scale 'Waste to Wealth' Program through bioconversion of Coir Pith and Press Mud- High GHG Emitters and highly soil and water polluting materials; utilizing Novcom Composting Technology.

SUMMARY

Coir pith, a byproduct of coir industry can take decades to decompose when left untreated. Due to absence of effective and viable composting technology/ies for its effective bioconversion, dumping of coir pith in open lands leads to environmental pollution specially **METHANE emission**. Under IBM-IORF Sustainability project at Mandya, Karnataka, Novcom Composting Technology was utilized towards effective bioconversion of coir pith into safe and mature compost for sustainable soil health management and elimination of Chemical fertilizer, especially N- fertilizer.

Periodical study confirmed effective degradation of organic matter as demonstrated by the rapid decline of C:N ratio from 1:100 to <1:25, appreciation of total nitrogen by 98 percent and 60 % degradation of lignin within a 30 days' time period.

And the values are corroborated by the respective very high (*in the order of 10^{16} c.f.u. per gm or One Trillion Billion Microflora per ton compost*) population of bacteria, fungi and actinomycetes. Phytotoxicity Bioassay test values, **confirmed not only the absence of phytotoxic elements in compost, but also indicated that this compost can actually accelerate seed germination and root growth process.**.

Milestone-1 Summary

Study of the GHG mitigation potential during bio- conversion of coir pith utilizing Novcom Composting Technology **as per IPCC guideline**, indicated that, **this Composting Technology can be the most effective and economic option towards GHG abatement**.

Considering the reference value of 200 kg GHG emission per tonne, treated wet waste, during composting, **Novcom coir pith composting was about 31 times MORE EFFICIENT in terms of GHG mitigation, especially w.r.t. SOURCE POINT METHANE MITIGATION.** This might be due to the prolific (*in the order of* 10^{16} *c.f.u. per gm or One Trillion Billion Microflora per ton compost*) self- generated population of native microflora within the compost heap, that also speeds up the biodegradation process and alternately shortens the biodegradation period to 30 days.

Under IBM-IORF sustainability, 1000 ton of Novcom coir pith compost was made which potentially mitigated about 6000 ton GHG in terms of CO_2 equivalent.

In addition to on- field study, ACFA Version-1, a carbon Footprint Assessment Tool developed by IORF, was also utilized towards evaluation of the GHG emission/ mitigation under Novcom Composting technology.

The Pearson correlation coefficient (r) value (r = 0.9863) indicated that there was high degree of POSITIVE CORRELATION between measured and calculated GHG values and thus AFCA (version 1.0) can be utilized for GHG evaluation specially where Novcom Composting Technology is adopted.

Thus Novcom coir pith composting could be an important component towards attending the **Net Zero Goal, enable successful reclamation of degraded lands and improve crop productivity**; while also generating additional mandays and options for income generation; that can empower farmers' livelihood.

Demonstration of Sustainable Management Practice in Sugarcane Cultivation

SUMMARY

In India Karnataka stands 3rd in cane production next to Uttar Pradesh and Maharashtra States and 2nd with respect to sugar recovery after Maharashtra. The state contributes 11.53 per cent of production and 8.83 per cent of the area. It has the second highest productivity, followed by Tamil Nadu.

While Mandya is known as Karnataka's sugar bowl, the district has lost that status to Belagavi, that has overtaken Mandya in terms of Sugarcane Production in the recent years.

Sugarcane is the third largest crop grown in the district in terms of the sown area but while Karnataka has witnessed positive growth, in **Mandya; productivity has actually reduced by 18%.** Moreover, **while sugar content has increased in Karnataka by about 16%, in respect of Mandya it has actually depleted by about 4%.** Scarcity of quality planting material also forms a major challenge for these sugarcane farmers.

Climate change forms a major bottleneck, but among the other constraints, depleting soil quality, and the rising incidence of pests and disease are the major cause of concern. **If the soil deterioration continues and the crop productivity goes down, the already low sugar recovery will be like a double whammy effect on the Mandya Sugarcane growers.**

Another Critical Component is the **RISING COST OF CULTIVATION** primarily due to **Rise in the Pest/ Disease Incidence**, leading to Higher Requirement of pesticides along with the Rising Cost of Chemical Inputs i.e., fertilizers and pesticides. **But the farmers have no choice in respect of Reducing the Chemical Load due to Complete Lack of Effective Technology/ ies in this respect.**

These very limitations formed the objectives for this intervention.

Milestone-2 Summary

Hence, the Clean Sugarcane 'NET ZERO' program was taken up under the Project with the adoption of **Inhana Rational Farming (IRF) Technology– A Comprehensive Crop Technology for Safe & Sustainable Crop Production.**

Attaining 'NET ZERO' Status – A 1st of a Kind Initiative in Sugarcane Cultivation

This Program aims at demonstrating the Pathway for Net Zero GHG Emission in Agriculture through GHG Omission from Source, GHG Abatement during crop production and through High C- sequestration in Soil. The Dual Approach of Inhana Soil Health Management & Plant Health Management in this program was aimed at attaining these very objectives.

Pic. : Planting of Sugarcane seed material in marginal soil, having <1.0% Organic carbon and close to 50% gravels

Bioconversion of raw coir pith into Stable, Mature and Non- phytotoxic compost within a shortest period of time (30 days) demonstrated **GHG Omission especially METHANE from this Very High GHG emitting Waste**. On- farm produced **Novcom Coir pith Compost** at 40 ton/ ha as well as various organic concoctions were used for **SOIL HEALTH MANAGEMENT** towards **elimination of Nitrate Fertilizers. The approach** on one hand demonstrates **GHG Mitigation from Source** while also aiming at Restoration of Soil Biological productivity, towards **Higher Soil-C Sequestration**.

Inhana PLANT HEALTH MANAGEMENT (IPHM), driven by Inhana '**ENERGY SOLUTIONS**' has been adopted towards reactivation of Plant Physiology - for higher agronomic efficiency leading to Sustained/ Higher Crop Yields. This approach also **Curtails the Accumulation of Ready Food Source** for Pests, in Plants' Cell Sap to **Discourage Pest Incidence leading to the ELIMINATION OF PESTICIDES. Evaluation of Crop Yield and Sugar content on Clean Sugarcane 'Net Zero' will be done when the Crop will be ready for harvest around June.**

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MILESTONE 3

New 100 hectare Project- Mandya, Karnataka

Demonstration of Sustainable Management Practice in Vegetable Cultivation (Model Plots).

SUMMARY

The total geographical area of Mandya district is 4,98,244 hectares, out of which 2,48,825 hectares forms the sown area. That means more than half of the district's total land area is used for agricultural purpose.

In terms of the Net Sown Area (NSA), the major crops of interest are Millets (32%), Rice (32%), Sugarcane (12%) and Coconut (8.4%). **Only about 2-3% NSA is under Vegetables. However, these endless rows of a single crop (mono cropping) year after year**, continuous application of chemical fertilizers especially nitrates and lack of soil health management **has initiated the cycle of soil depletion and led to higher and repeated pest leading to a higher application of pesticides and therefore a highly toxic and unsustainable environment that is threatening the farmers' livelihood.**

The soils of Mandya district are inherently thin gravelly and underlain with a murrum zone containing weathered rock. The soils are highly leached and poor in bases and the water holding capacity is low. **The high gravel content of the soil (sometimes upto 50%) coupled with Very Low Soil Organic Carbon means the soil are HIGHLY PRONE TO EROSION and this proneness has become multifold with repeated and high and injudicious fertilizer application. The fact is vividly demonstrated by the MODERATELY ERODED SOILS that measure 249,166 ha and account for about 50.28% of the total geographical area of the district.**

Among the challenges faced by the District Farmers Four, are Critical and Need Immediate Attention to Ensure both Present and the Future Crop Sustainability :

Soil Degradation

Increasing Incidence of Pest and Disease

Rising Cost of Cultivation

Milestone-3 Summary

While some efforts are being made through programs such as the Integrated Watershed Management, **Effective Models are Still lacking that can Singlehandedly Mitigate all the three Constraints.**

Coconut is a major crop in Mandya, but in the last 10 Years its yield has drastically reduced and is now about 50% lower than the Highest Producing State and 30% lower than the National Average. In this respect, **coconut based intercropping can help out in improving the output and economic return from these plantations**. **But only those intercropping models that encompass safe and sustainable agriculture, can ensure the desired benefits.**

Coconut based 'Net Zero' Intercropping Model was initiated under IBM-IORF Sustainability Project. **This Approach is Significant considering the fact that WASTE generated from Coconut Processing i.e. Coir pith was recycled into the plantation** post bio- conversion under Novcom Composting Technology to serve **TWO OBJECTIVES :**

- **Demonstrate 'Net Zero' Vegetable Cultivation as intercrop in Coconut Plantation**
- **Improve the Productivity of the primary Crop- Coconut**

This Model not only **enhanced the System Productivity By 442 %** **with incorporation of VEGETABLES AS INTERCROP,** the initiative also **enhanced the ENERGY EFFICIENCY** (in terms of crop productivity per unit of energy investment w.r.t nutrient management) **by 822 %. GHG assessment was also done under this Program.** The major mitigation was obtained from coir pith bioconversion into safe and mature Novcom compost that was utilized for soil health management in the platation w.r.t both coconut and vegetables; which were grown as intercrops. So far it is indicated that **this agriculture model, can potentially offset more than 500 MT CO_2 eq /ha,** and it **can be one of the MOST SUITABLE MODELS for any NET ZERO INITIATIVE, that can simultaneously Enhance the Livelihood of Coconut Growers.**

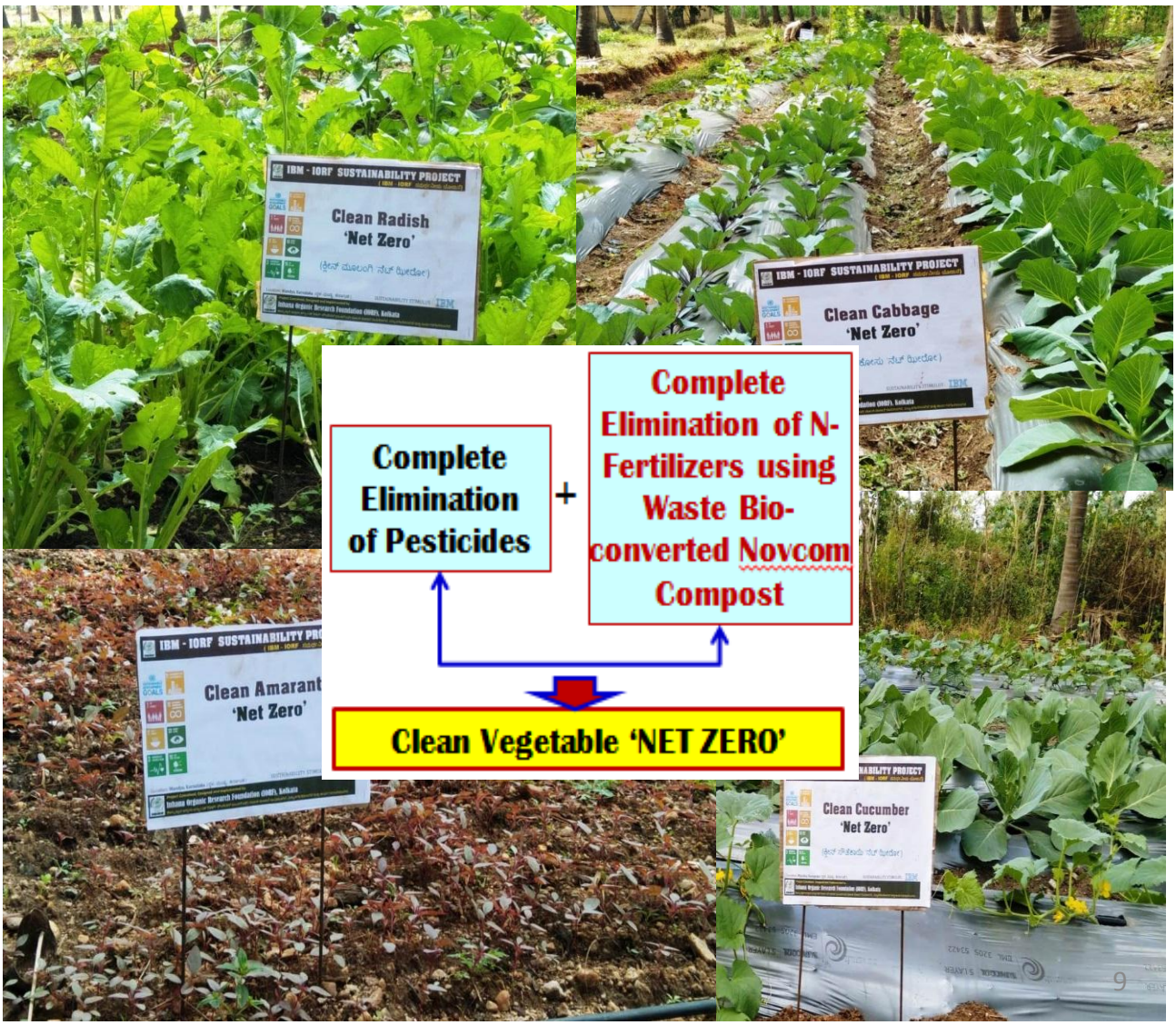
Milestone-3 Summary

The Coconut- Intercropping Model driven by IRF Technology

Attaining 'NET ZERO' Status– A 1st of a Kind & a Numero Uno Initiative in Vegetable Cultivation that too in Agriculturally Unsuitable Soils

The Phase-I Project had Conclusively demonstrated the critical relevance of Inhana Plant Health Management towards the objective of SAFE Food 'CLEAN FOOD' – Safe for Human Health

Addition of INHANA SOIL HEALTH MANAGEMENT through Waste Recycling along with Inhana Plant Health Management demonstrates a 1st EVER and a STUPENDOUS MODEL for SAFEST Food– CLEAN FOOD 'NET ZERO'- Safe for Human Health, Soil & Environment



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MILESTONE 4

New 100 hectare Project- Mandya, Karnataka

Development of Clean Food 'NET ZERO' encompassing THREE LAYERS OF SAFETY- Safe for Human Health, Safe for Soil Life & Safe for the Environment.

SUMMARY

Climate change is sowing the seeds of food crisis in its path. **Agricultures' vulnerability to climate change is reflective in the depleting crop yields especially under the extreme climatic events and the rising pest intensity.**

Besides climate change, **SOIL DEGRADATION** which contributes to 36–75 billion tons of land depletion every year, threatens the global food supply; which implies that now; More Crop has to be Produced from Less Land.

Hence, the major challenge facing mankind today is to produce sufficient food, for the rising human population, from a comparatively lesser land, while combating the climate change impact.

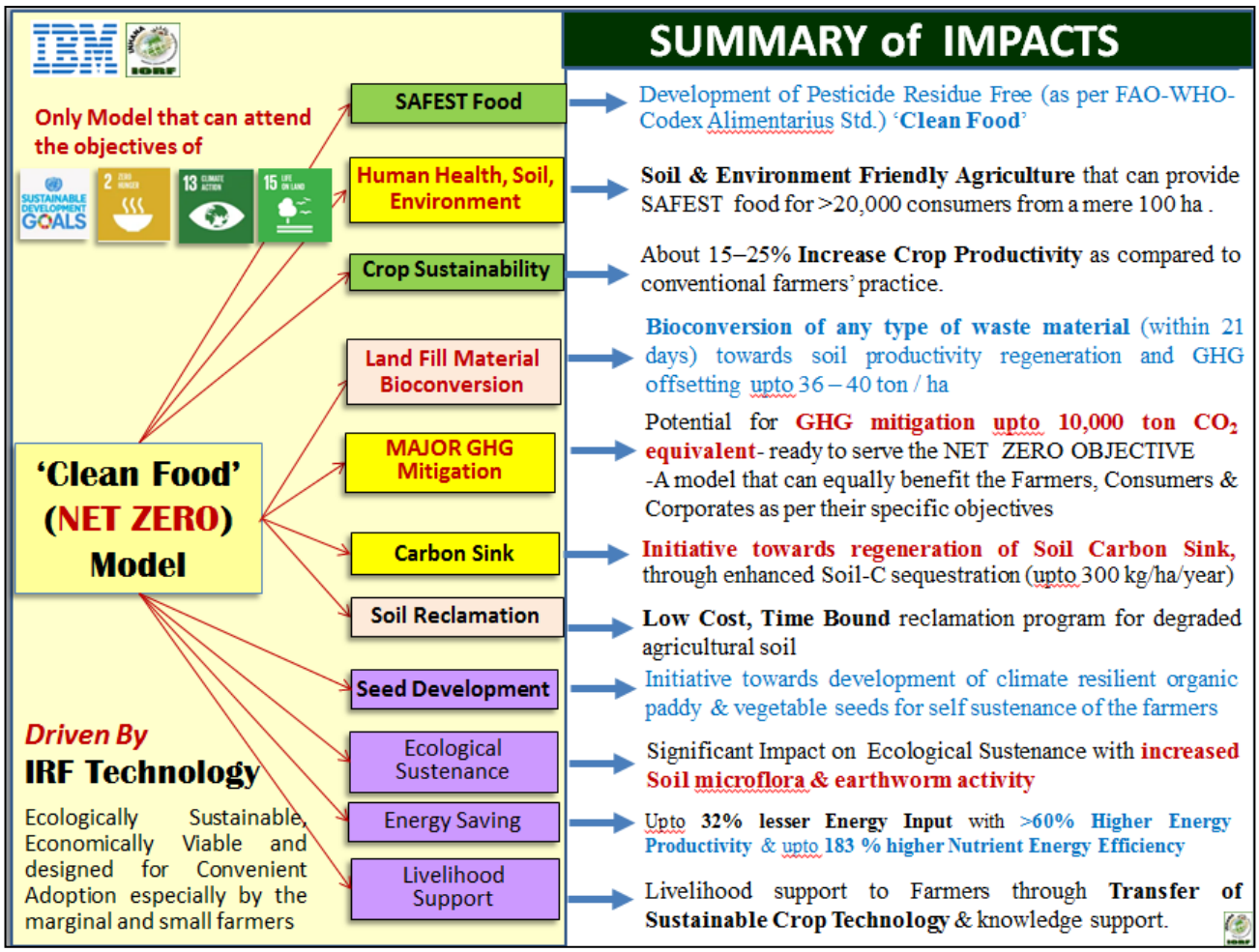
Sustainable Soil Management in terms of lowering/ eliminating fertilizer use, especially nitrate fertilizers and higher application of microbial (self- generated) rich organic amendments for improving the Soil- C sequestration can serve towards GHG mitigation. **Healthy soil will also support better crop performance that can serve the adaptation strategies.**

Two initiatives, i.e., increasing the productivity of Marginal Soils and Reclamation of Degraded Soils for restoring its suitability for agriculture; though herculean tasks can provide significant impact in this arena.

In the Phase-I Project, IORF demonstrated the pathway to produce **'Clean Food'- Safe for Human Health and Sustainable for all**, with an impact area in respect of SDG-2 'Access of Safe and Nutritious Food' for all (SDG 2.1).

Hence, in the Phase-II Project at Mandya District, IORF initiated the Clean Food 'NET ZERO' Model towards SAFEST FOOD production i.e., Safe for Human Health, Soil and the Environment, through elimination of both Chemical-Fertilizers and Pesticides. Inhana Rational Farming served as the interventional Crop Technology

Milestone-4 Summary



In the Mandya District of Karnataka, more than half of the total land area is used for agricultural purpose. But **Only about 2-3% of the Net Sown Area is under Vegetable cultivation.** This initiative under Phase-II Project **demonstrates the Potential for Vegetable Cultivation specially undertaking a Safe and Sustainable Agricultural practice. But apart from vegetables paddy, maize and ginger were also taken under this initiative.**

This was a CONSIDERABLE LEAP denoting the fact that about 50.28% of the total geographical area of the district represent MODERATELY ERODED SOILS. The Model Farm selected for the program was an exact representation of such soils as depicted by Very Low Soil Organic Carbon (0.5 to 0.6%) and more than 50% Gravel Content that pose major challenges w.r.t. crop cultivation especially for vegetable crops.

Milestone-4 Summary

Crop		Yield (Tonne/ ha) under Conventional Farmers' Practice	Clean Food 'NET ZERO' Yield (Tonne/ ha)
BRINJAL	:	15.4-23.4	26.1
RADISH	:	14.1-18.4	19.6
FRENCH BEANS	:	7.4-9.4	10.8
CAULIFLOWER	:	18.4-24.6	26.1
CABBAGE	:	20.6-24.4	28.1
KNOL KHOL	:	16.6-18.7	20.2
CAPSICUM	:	12.1-14.6	15.8
CUCUMBER	:	13.4-15.1	16.2
TOMATO	:	21.1-26.6	28.4

Crop		Yield (Tonne/ ha) under Conventional Farmers' Practice	Clean Food 'NET ZERO' Yield (Tonne/ ha)
CHILLI	:	8.1-10.6	11.4
PUMPKIN	:	18.4-22.6	24.4
BITTER GOURD	:	9.4-11.6	12.4
BOTTLE GOURD	:	15.6-18.4	21.6
RIDGE GOURD	:	16.0-18.0	24.6
OKRA	:	9.2-10.8	11.6
SPINACH	:	10.2-12.4	12.8
CORIANDER	:	3.62-4.20	4.25
RED AMARANTH	:	12.0-16.0	16.2

Crop		Yield (Tonne/ ha) under Conventional Farmers' Practice	Clean Food 'NET ZERO' Yield (Tonne/ ha)
PADDY	:	3.85-4.25	4.02-4.65
MAIZE	:	2.7-3.2	29.4-34.6
GINGER		8.6-12.4	9.2-13.7

On an average the yield of all the crops under Clean Food 'NET ZERO' Model was close to 10% higher as compared to yield obtained under the conventional farmers' practice.

For crop varieties like bottle gourd, French beans, cabbage., etc. about 15-20% higher yield was obtained, under this model.

Higher Crop Yield (*especially in the case of paddy*) was a Phenomenal Achievement because it was obtained under complete elimination of N- fertilizers and chemical pesticides. This indicated the Relevance of Inhana Plant Health Management (IPHM) and the effectiveness of Novcom Coir- pith Compost, towards Climate Resilient, Safe & Sustainable Crop Production.

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MILESTONE 5

New 100 hectare Project- Mandya, Karnataka

Safety Authentication of Clean Food 'NET ZERO' using the Food Safety Assessment Tool.

SUMMARY

The Phase-1 of Project Demonstrated the **'CLEAN FOOD' MODEL- SAFE** for Human Health @ Same Cost, Hence Sustainable for All - **aligned with SDG-2**, **that can be Adopted across Agro-ecological Zones and variable Farm Economies.**

Moreover, Clean Food means Safety Authentication NOT BY AUDIT but through ACTUAL ANALYSIS

The **chromatographic technique** for residue analysis however, is **hugely expensive, complex, time-consuming and require specific resources and infrastructure** which offer major hindrance towards regular analysis for monitoring of food safety. Especially for a country like India, with **absolute dominance of marginal farmers in vegetable cultivation**, lack of awareness, resource scarcity, inability to take economic risk and flaws in maintaining the standard practices w.r.t. chemical usage; enhances the availability of pesticides in food product. **Moreover the short time gap between the field harvest of vegetables and consumption, limits the scope for safety analysis even if the infrastructure and economics is not considered.**

In this background an **effective, speedy, yet an affordable method** was needed to enable pesticide residue analysis in situations of limited resources, more so for safety authentication of Clean Food.

In this respect the **Colorimetric Assay Test** was identified as a solution that can tick off all the requirements. The Colorimetric Pesticide Assay Test can serve as the **MOST STRINGENT TEST** for Food Safety, due to the scope for detection of the Collective Presence/ Absence of the Pesticide Residues up to the Lowest- Group Specific Permissible Limits. **And Most Importantly at just 1/10th of the Conventional Cost of Residue Analysis. This test method was utilized under Phase-II Project to evaluate the Safety Aspect of Clean Food 'Net Zero'.**

Milestone-5 Summary

Comparative Safety Assessment of 18 different varieties of vegetables (*viz. brinjal, radish, French beans, cabbage, capsicum, cucumber, tomato, chilli, red amaranth, bitter gourd, etc.*) developed under **Clean Food 'NET ZERO' Model (in Model Farm)** was done **vis-à-vis organic vegetables as well as the conventionally grown counterparts.** A total of **224 Samples** were studied for the purpose

While **No Residue** was detected in respect of the Clean Food 'NET ZERO' and Organic Samples; **44% *(on an average)* of the conventionally grown vegetables were found to be tainted with pesticides.** Out of the conventionally grown vegetables chances for pesticide residue was found to be highest in the case of brinjal followed by French beans and cucumber and lowest for pumpkin.

Clean Food 'NET ZERO' Safety Assessment- **THE MOOT POINTS**

- **Clean Food 'NET ZERO'** – SAFEST FOOD – SAFE for Human Health, Soil & Environment. Also SAFETY is the Cursor for **SUSTAINABILITY.**
- For Safety Authentication of Clean Food 'NET ZERO', especially for Multiple Harvest Crops like vegetables- **Batch wise Testing was a must**.
- But the Conventional Process of Pesticide Analysis is **COSTLY & TIME CONSUMING**– due to high investment, lack of infrastructure, resources and technical manpower.
- **Hence, frequent Safety Assessment of Produce especially multiple harvest crops like vegetables is beyond question** because majority of the growers are small and marginal land holders.
- The **Colorimetric Pesticide Assay Test developed in Phase-1 of the IBM-IORF Sustainability project** came out as the Right Solution considering that it can enable **Both Qualitative & Quantitative Residue Analysis,** at **1/10th of Conventional Cost and Time required for Analysis** *(respectively).*

Soil Quality Appraisal of the Project Area & Soil Health Card for the farmers.

SUMMARY

Soil health is an integrative property that reflects the capacity of soil to respond to agricultural intervention, so that it continues to support agricultural productivity, food quality, environmental resiliency, and ecosystem sustainability. Soil health plays an important role in agricultural productivity, food quality, environmental resiliency, and ecosystem sustainability as **HEALTHY SOILS PRODUCE HEALTHY CROPS** that in turn nourish people and animals (FAO, 2015)

But Most Importantly, the knowledge about Soil Health Status is Crucial in order to judge what steps to undertake for Sustainable Soil Management.

10 hectare Grid was considered for soil sampling and samples were collected from the project area. **The soil of Mandya district is derived from granites and gneisses and the texture range from red sandy loams to red clay loam very thin on ridges and higher elevations and comparatively thick in valley portions.**

The soil analysis data was evaluated in respect of seven different land use types in order to provide a basic idea regarding the soil health status under different anthropogenic use

The soil is light in texture, with very low organic carbon (0.42 to 0.57 %.) and low bulk density (1.26 – 1.48 gcm^3). Moreover, presence of small to medium gravels (40 to 60%) **hinder proper root penetration in soil increasing the proneness to abiotic stress.**

At the same time, due to higher sand percent, gravel content and lack of organic matter in soil, soil aggregates in majority area is very low to low and **prone to soil erosion specially in the undulating plains.**

Milestone-5 Summary

In general the low organic carbon and humus content in red soil causes an inherently lower microbial activity, and conventional agricultural practices in such soil further depletes the microbial status.

The other biological parameters also depict poor biological activities in the soil **which is major cause of concern both in respect of crop sustainability as well as soil erodibility potential.**

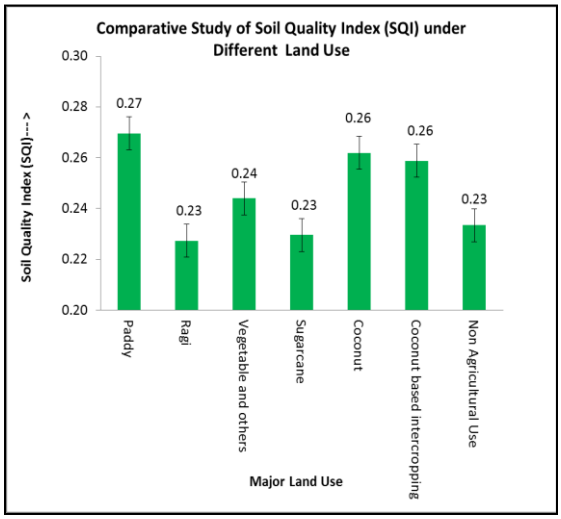

Fig : Comparative Study of **Soil Quality Index (SQI)** under Different Land Use at Mandya, Karnataka

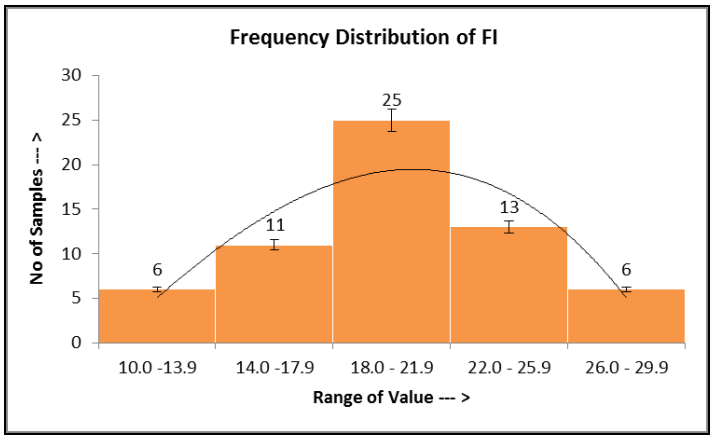

Fig : Frequency Distribution of Fertility Index (FI)

- The Microbial Activity Potential (MAP) was very low in most of the soil indicating limited biological activity- could cause major limitation towards crop sustainability.
- **SQI value was found to be very low in most of the soil, primarily due to poor to very poor microbial activity and limitation w.r.t. soil physical characteristics**

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MILESTONE 7

New 100 hectare Project- Mandya, Karnataka

Development 'Reclamation Model' for converting Degraded Land to Agriculturally Suitable Land through adoption of IRF Technology.

SUMMARY

29.7% (97.85 mha) of India's Total Geographical Area has already undergone Land Degradation. Some 83.69 mha underwent desertification in 2018-19 (*Desertification and Land Degradation Atlas of India*). In last 13 -14 years, about 3.32 million hectares has been degraded. India has a **National Commitment** for 'Restoration of 26 mha of degraded land by 2030' *(14th Session of the Conference of Parties of United Nations Convention to Combat Desertification (UNCCD), 2021.*

Some of the most primary impacts of Soil Degradation

- Loss of Soil Productivity
- Loss of crop productivity
- Loss of Biodiversity
- Loss of Livelihood support
- Increase in Green House Gas (GHG) Emissions

It is necessary to halt Soil Degradation and undertake Reclamation of Degraded lands **from the Food Security objective as well as to sustain Farmers' Livelihood**; but more so to **Reduce the Total Projected Carbon Emissions by one billion tonnes** by 2030- India Commits; and this will require a significant contribution from agriculture & forestry– the largest potential sink w.r.t. GHG Mitigation opportunities.

SOIL BIOLOGICAL PRODUCTIVITY IS THE KEY for Reclamation of Degraded Land.

Bur restoration of Soil Biological Productivity is a very difficult task considering that the Top 6 inches or 15 cm of Soil in 1 hectare area weighs about 22,40,000 kg, so application of a high dose of compost like **22 Tons, will actually add only about 5 g Organic Matter per kg soil- Consequently, this will provide just 0.1% Organic Carbon in the Top 6" Soil in 1 hectare area.**

The Indian Soils on an average contain about 0.5% Organic Carbon. Hence, on a large scale even if a modest target of increasing Soil Organic Carbon to 1% is set, it will require **110 Ton of compost per hectare.**

Milestone-7 Summary

It is Not the Organic Matter Load or Organic Carbon Load , rather the COMPOST MICROBIAL LOAD IS THE KEY TO ACCOMPLISH THE TARGET. But the Microbial Load should be Inherent to the Compost, Self- generated under the Composting Process and Well Diversified

Biodegradable Waste of any kind especially landfill material can best serve the objective. But technology is crucial for their bioconversion into Safe & Quality Compost. **Coir pith,** an agro waste; is dumped in open lands and forms a major soil and water pollutant, besides being a Very High GHG Emitter (6.0 mt CO_2-eq per ton approx.), primarily METHANE, which has 75 times Higher Global Warming Potential as compared to CO_2. **Karnataka alone, Produces about 5,00,000 - 6,00,000 ton of Coir Pith annually.**

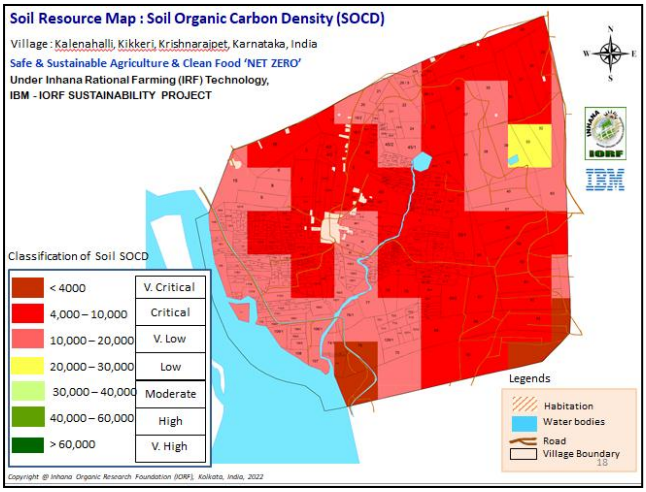
The **IBM-IORF Sustainability Project** Demonstrated that Coir-pith can Serve as an **Excellent Resource for Soil Health Management** when bio- converted into a Stable, Mature & Non-phytotoxic Compost – **1st Ever in Indian Agriculture**. **1000 ton of Coir pith was bio- converted and use for Soil Health Management.**

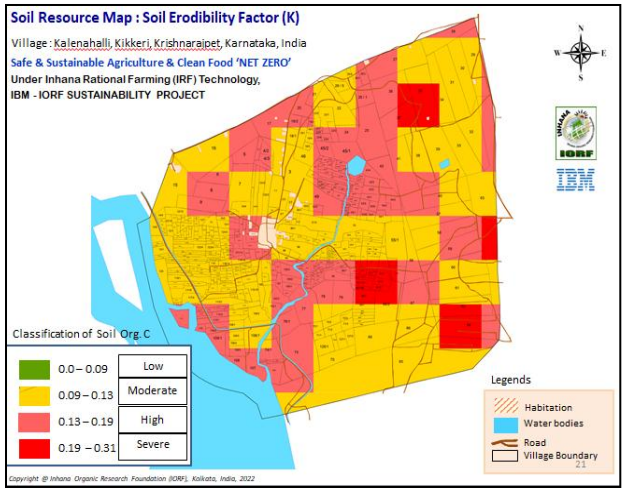
A Study was undertaken to assess the Soil Organic Carbon Density (SOCD) to understand the overall soil organic carbon stock in the major root zone (30 cm). **The Study revealed that majority (60%) of the area was under critical to very critical zone.** This together with the physical characteristics of soil pointed towards a Higher Potential for Erosion and a low Soil Productivity Potential.

Evaluation of Soil Erodibility (K) of the project area revealed a moderate soil erosion susceptibility in a majority (57%) area. **Also about 7% and 36% area suffered from severe and high soil erosion respectively, which is a major concern point.**

The evaluation indicated that there was **high risk of top soil loss if proper measures are not taken,** which is a **major concern point for crop sustainability specially considering marginal soils with an inherently poor soil quality.**

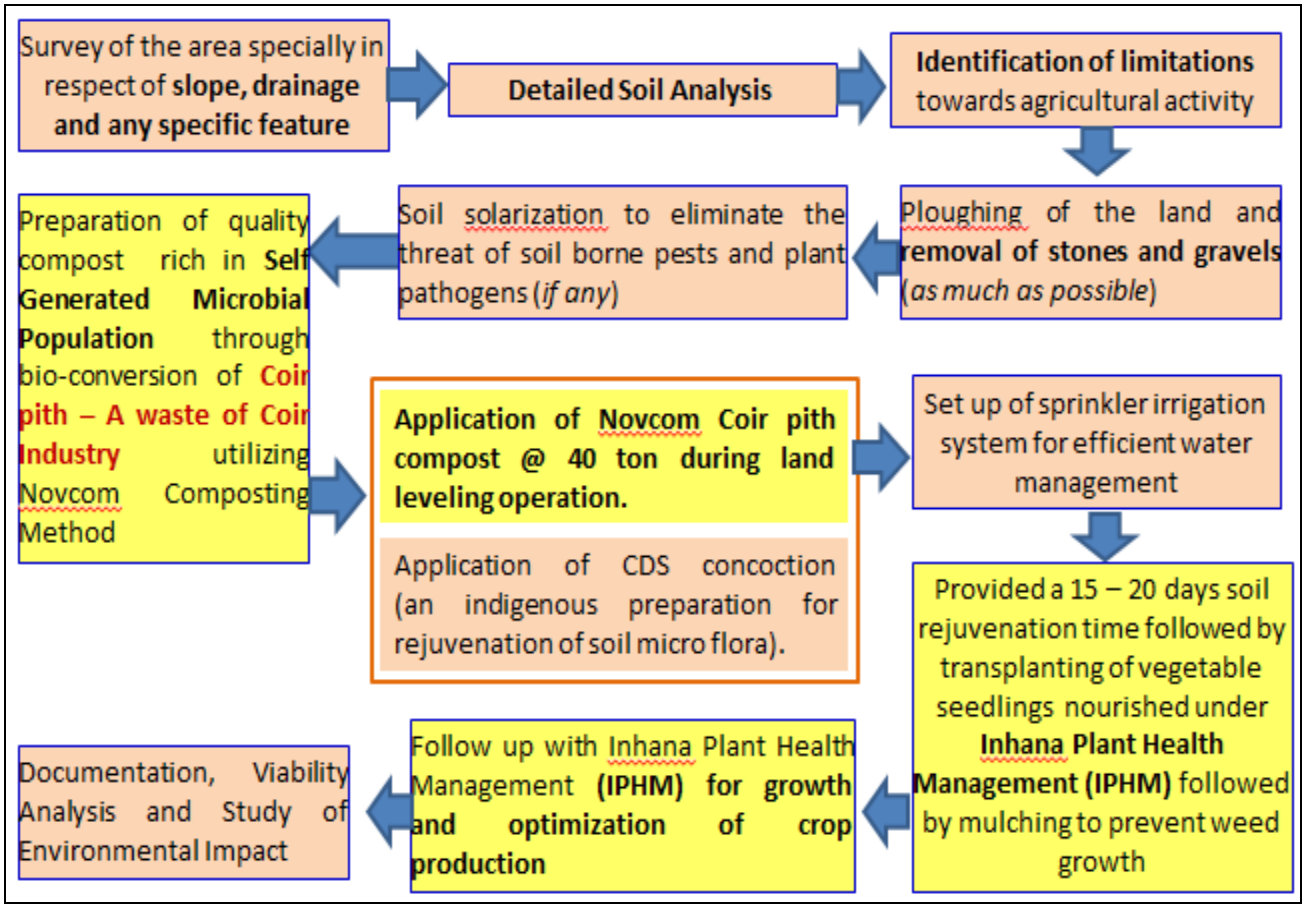
Milestone-7 Summary





Resource Maps showing Soil Organic Carbon Density & Soil Erodibility Factor in the Project Area

Flow Diagram of Soil Reclamation Model under IBM – IORF Sustainability Project



IBM Corporate Social Responsibility

MILESTONE 8

New 100 hectare Project- Mandya, Karnataka

Developing a GHG Mitigation Model with added Social and Environmental Impact and a potential for mitigating 30 – 40 lakh metric ton CO_2 equivalent/ year, in India.

SUMMARY

Climate change is now affecting every country on every continent, disrupting national economies and affecting lives, costing people, communities and countries dearly today and even more tomorrow. The poorest and most vulnerable people are being affected the most. Disruption in crop production system due to **climate change impact will be a major threat towards mitigation of GLOBAL HUNGER** as **50% Higher Food Production will be required to meet the Food Requirement by 2050.** While Agriculture faces the major challenge w.r.t. climate change, it is also a major contributor to climate change, being the second largest emitter of GHGs. But it is also the only sector, which can enable both GHG mitigation and Adaptation.

Under IBM-IORF Sustainability Project at Mandya, Karnataka, an effort was initiated utilizing Novcom Composting Technology, towards effective **BIOCONVERSION OF COIR PITH** into safe and quality compost for sustainable soil management, **to establish a GHG Mitigation Model in Agriculture that will demonstrate both Environmental and Social impacts.** The GHG offsetting potential under Novcom Composting Technology was documented **through actual field study and also evaluated using ACFA (Version 1.0) – Agriculture Carbon Assessment Tool** developed by IORF as per Intergovernmental Panel on Climate Change (IPCC) guidelines (2018).

The significance of this initiative can be judged from the fact that it demonstrated a FIRST EVER MODEL for METHANE MITIGATION in agriculture - a critical GHG considering that it traps 80 times more heat in the atmosphere than CO_2 (The Associated Press, 2022) over the first 20 years after it reaches the atmosphere. Also, methane sets the pace for warming in the near term (EDF, 2022) as it has a radiative forcing approximately 120 times more than CO_2, and it also forms ground-level ozone, a hazardous air pollutant and greenhouse gas, exposure to which causes 1 million premature deaths every year.

Milestone-8 Summary

Debate on GWP of Methane on 100 Years Basis or on a Shorter Scale

Scientists have recognized **that acting now to reduce methane emissions** will have immediate benefits to the climate that reductions in carbon dioxide cannot provide on their own (EDF, 2022). But there is an emerging debate whether, GWP of methane will be taken on 100 years basis (as IPCC recommended) or on a shorter scale. Today more scientists are beginning to model the warming effects that today's methane emissions will have over the next 20 or 30 years, in order to **predict more accurately whether humanity can avoid overshooting targets such as stopping global warming at 1.5 degrees Celsius.**

In the latest IPCC report [2021], it has been clearly maintained that, IPCC does not recommend an emissions metric because the appropriateness of the choice **depends on the purposes for which gases or forcing agents are being compared**. Emissions metrics do not define policy goals or targets but can support the evaluation and implementation of choices within multi-component policies (e.g., they can help prioritize which emissions to abate). **The choice of metric will depend on which aspects of climate change are most important to a particular application or stakeholder and over which time horizons.**

- Evaluation revealed that untreated **coir pith can potentially emit methane in the range of 5897 – 6025 kg CO_2 equivalent** (taking $GWP_{24\ years}$ of methane: 75).
- Methane emission was found to be **NEGLIGIBLE (0.61 kg CO_2 equivalent per ton wet coir pith)** under Novcom Composting Technology, **as compared to that documented (2.25 – 600 kg CO_2 eq/ ton wet waste, considering $GWP_{24years}$ of CH_4 : 75) for other standard biodegradation processes**
- The **Total GHG Emission** during coir pith bioconversion under Novcom Technology, was about **31 TIMES LOWER (6.47 kg CO_2 eq/ ton treated waste)** than the reference values **(200 kg kg CO_2 eq/ ton treated waste)** recorded in respect of any other standard biodegradation process.

The GHG Mitigation Model developed under Phase-II Project can enable Methane Mitigation of about 6000 ton CO_2 eq per 1000 ton WASTE, directly from SOURCE POINT, while Also Improving Soil Health & Farmers' Livelihood .

Development of Resource Maps of the Project Area

SUMMARY

Soil Resource Mapping and development of thematic maps is the most useful tool for identification of potential and problematic areas in order to enable the formulation of an effective and customized soil management program.

Soil evaluation especially in terms of the microfloral activity and soil quality; followed by resource mapping can enable the maintenance of soil resource base while tapping the potential areas simultaneously, with the target of better farm maintenance.

It can also help to **prevent soil degradation with good planning, reduce the costs of remediation when it is necessary, and contribute to issues related to climate change (e.g., reduction of greenhouse gas emissions)** and human health (e.g., soil contamination). **Also, without access to information regarding soil quality; farmers are prone to use higher and injudicious amount of fertilizers.** In this respect, incorporation of detail soil maps in the precision agriculture database can make considerable contributions to decreasing fertilizers (Cullu, 2019).

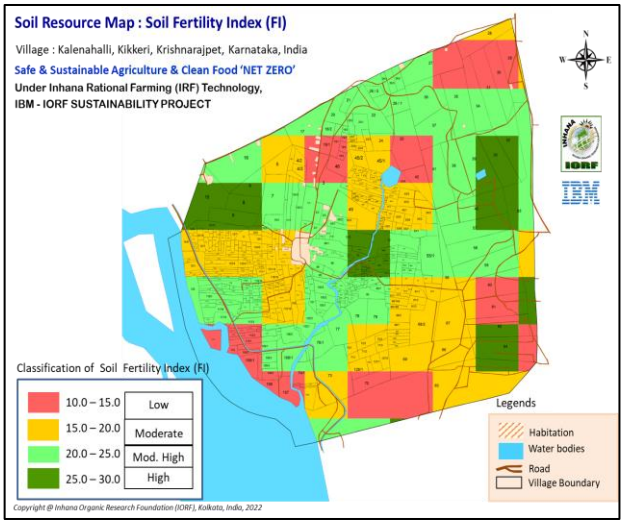
Significance of Soil resource mapping increases manifold especially in respect of Sustainable Soil Management, where judicious application of organic soil inputs has a direct bearing on the practical feasibility and the related economics; especially considering the existential scarcity of resources for on-farm production of quality compost in the required quantity.

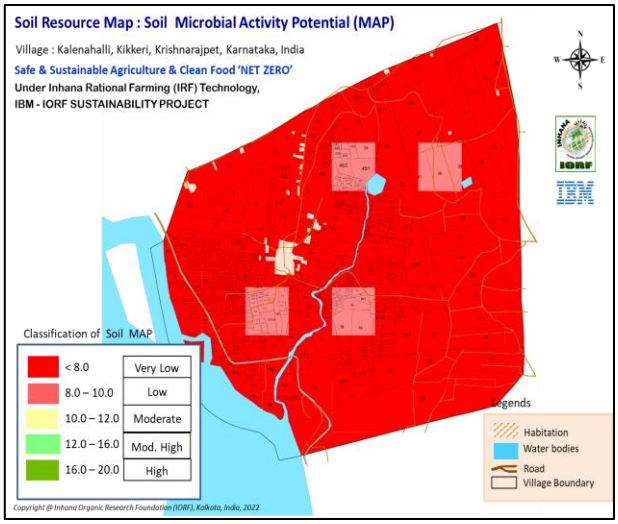
In the Phase-II project 18 different Resource Maps were developed for the project Area, towards the objective of Sustainable Soil Resource Management.

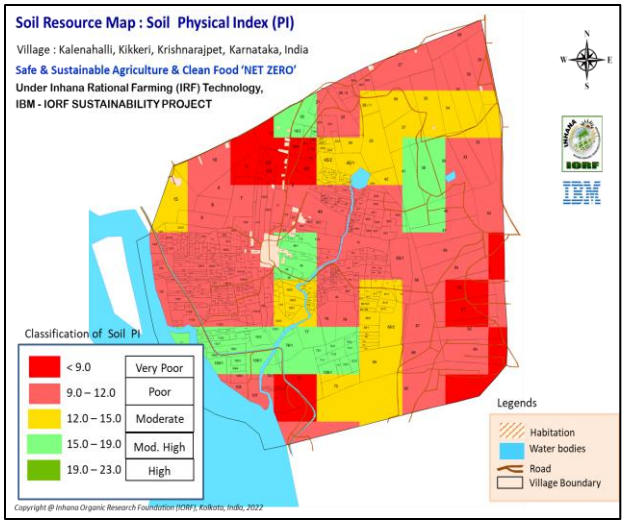
The Soils were analyzed for physical, physicochemical, fertility and microbial properties as per standard guidelines. The area is a combination of plain and undulating plains with mostly reddish colour soil with 40 to 60 % gravel content.

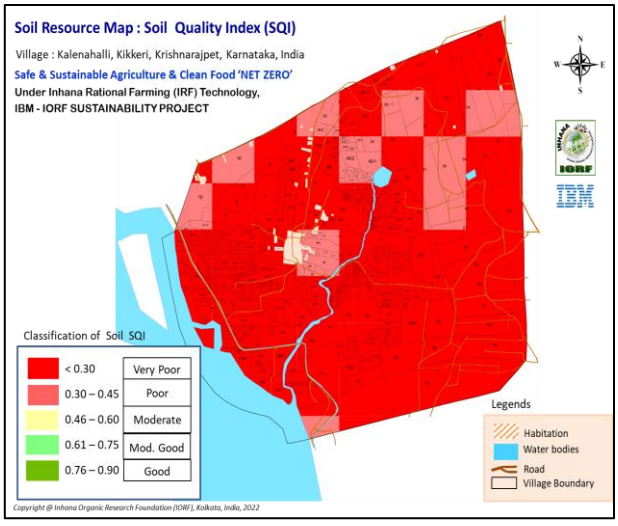
Milestone-9 Summary

As per textural class , the soils varied from sandy loam to sandy clay loam, sand percentage varying from 59 to 86 percent. Though the soils are light textured but due to presence of small to medium gravels proper root penetration is hindered. Soil organic carbon is one of the most limiting factor in the project area, mean value under different land use varied from 0.42 to 0.57 %. Soil Quality Index (SQI) value in the project area was found to be very low in most of the soil, primarily due to poor to very poor microbial activity and limitation w.r.t. soil physical characteristics.









IBM – IORF

SUSTAINABILITY PROJECT

Adoption of a Cluster of Villages for Agricultural Sustainability and Food Security through Clean Food Program

PROJECT SITE :
Block– Haringhata, District- Nadia , State- West Bengal, India

Year 2022 - 23

MILESTONES

Summary of Project Achievements

IBM **Corporate Social Responsibility**

MILESTONES

1. SOIL HEALTH CARD OF INDIVIDUAL FARM LANDS FOR ABOUT 400 PROJECT FARMERS.
2. SOIL- SITE SUITABILITY EVALUATION OF MAJOR CROPS
3. MODEL DEMONSTRATION OF SAFE & SUSTAINABLE ‘CLEAN VEGETABLE SEED’ PRODUCTION.
4. DEVELOPMENT OF SUSTAINABLE IMPACT STORIES RELATED TO IBM SUSTAINABILITY PROJECT.
5. RESEARCH PUBLICATIONS BASED ON SPECIFIC SCIENTIFIC OUTCOMES.
6. MODEL DEMONSTRATION OF SAFE & SUSTAINABLE ‘CLEAN PADDY SEED’ PRODUCTION.
7. ESTIMATION OF ENERGY USE EFFICIENCY
8. ESTIMATION OF CARBON SAVING AND GHG MITIGATION
9. ANALYSIS OF SAFETY, QUALITY & SEED RESILIENCE OF CLEAN PADDY & VEGETABLE SEEDS
10. SAFETY AUTHENTICATION OF 'CLEAN FOOD' THROUGH 'FOOD SAFETY ASSESSMENT TOOL'

IBM **Corporate Social Responsibility**

MILESTONE NO. 1

SOIL HEALTH CARD OF INDIVIDUAL FARM LANDS FOR ABOUT 400 PROJECT FARMERS.

IBM **Corporate Social Responsibility**

Which IBM program is this grant for?

Other

Target Reporting Date

09/26/2022

Milestone Name

Continuation Project 100 ha -Comprehensive Soil Health Card of individual farm lands for about 400 Project farmers.

Milestone Goal

Enabling access of marginal and small farmers to complete soil health report of their individual farm lands, in order to enable sustainable soil management- the 1st Step in the Journey of Safe & Sustainable Agriculture.

Describe the expected progress toward the goal by this target reporting date.

Enabling access of Soil Health Card to about 400 Project Farmers by the target date.

Expected progress toward milestone goal, as a number

400

Expected Progress Units

Comprehensive Soil Health Card

MILESTONE NO. 1 - SUMMARY

In the Project area, the **small and marginal farmers comprise 96% of the Total Farmers** with an average land holding size <0.26 hec. that is less than 1/6th of the set limit (2.0 hec.). **But in stark contrast, the cropping intensity is very high (about 2.5 to 3.0),** meaning extreme dependence on land, and also extreme resource poorness due to the land demography. Hence, these farmers are in dire need of a sustainable pathway for crop production, **which starts with Soil Test Based Soil Health Management. But lack of access to Land Specific Soil Health Card is again an existential problem.**

The Soil Health Card that the Govt. of India (GOI) provide to the farmers evaluate soil in terms of only 12 Quality parameters, namely pH, EC, OC (Physical parameters), N,P,K,S (Macro-nutrients) and Zn, Fe, Cu, Mn, Bo (Micro - nutrients). **However, Soil Health Assessment in terms of mere physicochemical and fertility does not help** because sustainability issues are much broader and will be difficult to achieve **until strong emphasis is given to the dynamic soil property i.e. SOIL MICROFLORA**

Moreover in the present SHC protocol of GOI, only one sample is taken from a 2.5 ha grid (under irrigated ecosystem). But considering the average landholdings of marginal farmers (0.30 – 0.40), 6 – 10 farmers lands will fall under a single grid, which means all of them get the **Same Soil Health Card**. And as experienced from the ongoing IBM-IORF Sustainability Project in the Nadia District of West Bengal, India, **somewhere between 10 – 30 farm lands can be present within a single grid area which is the reality of fragmentation of land in West Bengal.**

Now despite different land use and management practice, the present system provides opportunity only for a single soil sample analysis, so has **very limited practical usage in respect of undertaking soil management in individual farm land based on the generalized analytical report.**

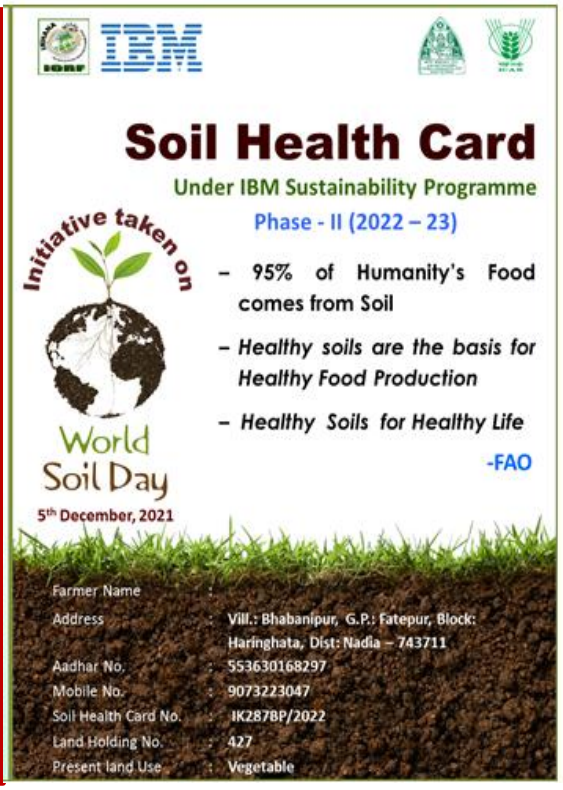
Hence, initiative was taken up for Soil Resource Mapping of the entire area with the objective of providing **Every Individual Project Farmer his own 'Soil Health Card' aligning with our mission 'KNOW YOUR SOIL'**.

Contd. . .

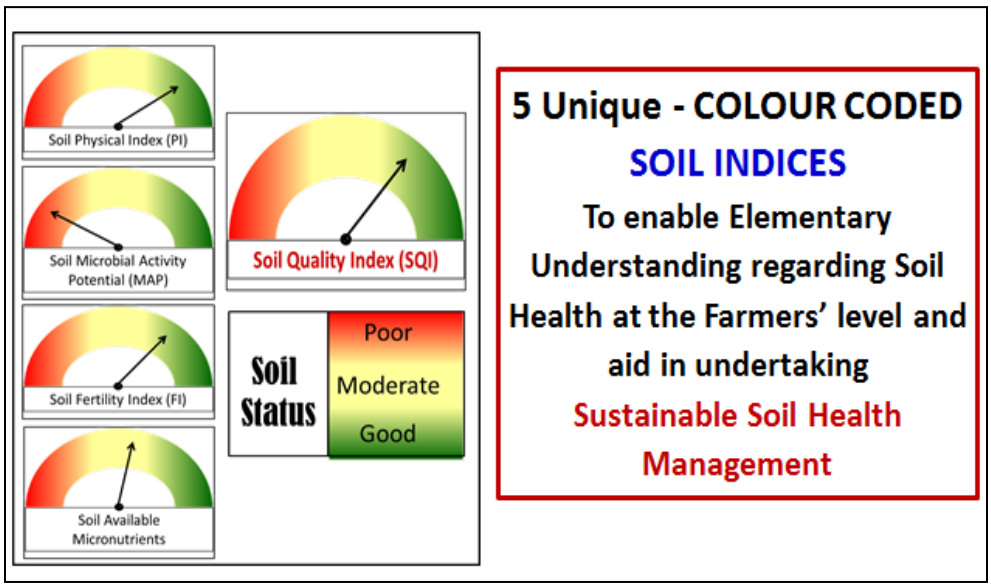
The relevance of IBM-IORF 'Soil Health Card' is paramount considering that sample analysis has been done on a grid of 0.26 ha as against 2.5 ha for normal testing protocol.

HIGHLIGHT

The GOI launched the Soil Health Card (SHC) Scheme in 2015, which was a first time crucial initiative post independence. The Soil Health Card developed under the IBM-IORF 'Clean Food' Project **can serve to strengthen the Govt. SHC Program due its Comprehensiveness** in terms of **25 Soil Quality Parameter** Analysis especially focusing on **Soil Biological Parameters**; that actually determines the soil dynamism and most importantly **'Soil Health'**.



Also **5 IMPORTANT SOIL INDICES** namely Physical (PI), Fertility (FI), Microbiological (MAP), Micronutrient and finally Soil Quality Index (SQI) as overall **SOIL HEALTH INDICATOR**; have been provided in **SIMPLE COLOUR CODING** to facilitate easy understanding by the farmers through visual interpretation.



Pic- Inside Right- page of the IBM-IORF Soil Health Card

IBM **Corporate Social Responsibility**

MILESTONE NO. 2

SOIL- SITE SUITABILITY EVALUATION OF MAJOR CROPS

IBM **Corporate Social Responsibility**

Which IBM program is this grant for?

Other

Target Reporting Date

09/30/2022

Milestone Name

Soil- Site Suitability evaluation of Major Crops.

Milestone Goal

The goal is to assess the suitability of the soil of the project area in relation to the major crops grown so as to evaluate their vulnerability under the existential climate change impact.

Describe the expected progress toward the goal by this target reporting date.

Expecting 100 percent completion of Suitability Evaluation of major crops by the Target Reporting Date.

Expected progress toward milestone goal, as a number

100

Expected Progress Units

Soil-site Suitability

MILESTONE NO. 2 - SUMMARY

Productivity of a particular crop depends on land resources and the climate of the area. The inherent ability of soils to supply nutrients for crop growth and maintenance of soil physical conditions to optimize crop yields is the most important component of soil fertility that virtually determines the productivity of agricultural system (Jayasree, 2022). **So, identification of crop requirements and matching them with the resource available to optimize the productivity in a sustainable manner assumes a greater importance as the present level of productivity of most of the crops has either reached the plateau or has started declining.**

Hence, Soil - site suitability evaluation is the pre-requisite for land use planning (Sys et al., 1993). Also as soil- site suitability evaluation clearly indicates the nature of constraints that hamper optimal production, scope remains for taking up proper reclamation and management of natural resources within the selected land use framework (Varheye, 1993). **Hence, from agricultural point of view, it helps in identifying the suitability of soils to produce different crops on a sustainable basis without degradation of the land.**

The importance of soil- site suitability evaluation has grown multifold considering the continuous depletion of soil as a resource under conventional agricultural practice. **Soil- site suitability of major crops was undertaken to assess whether the presently grown crops are appropriate for the area, and to ensure that the land use plan adopted by the farmers provides better economic returns and livelihood sustenance, under the existential climate change impact.**

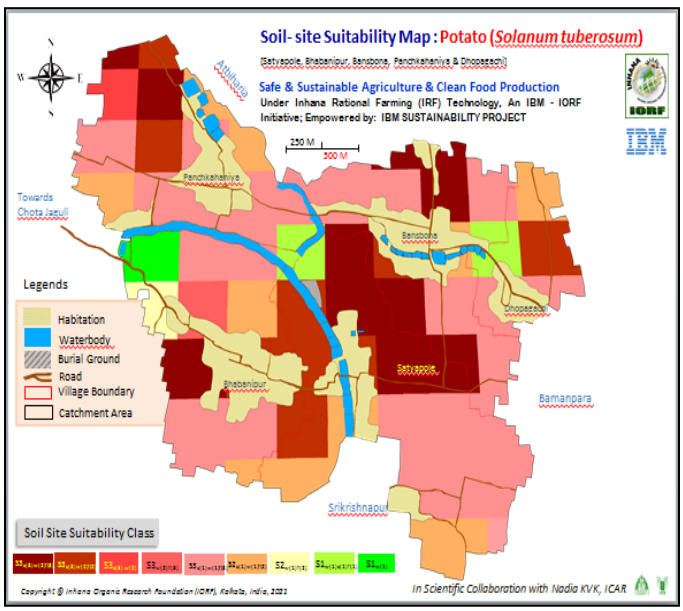
Soil site suitability evaluation was carried out following the criteria outlined by FAO [4], Sys et al (1993) and Naidu et al. (2005). The FAO framework involves formulation of climatic and soil-site criteria to meet the requirement of crops and rating of these parameters for **highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N) classes**. These were matched with existing land qualities to arrive at a specific suitability class.

Contd. . .

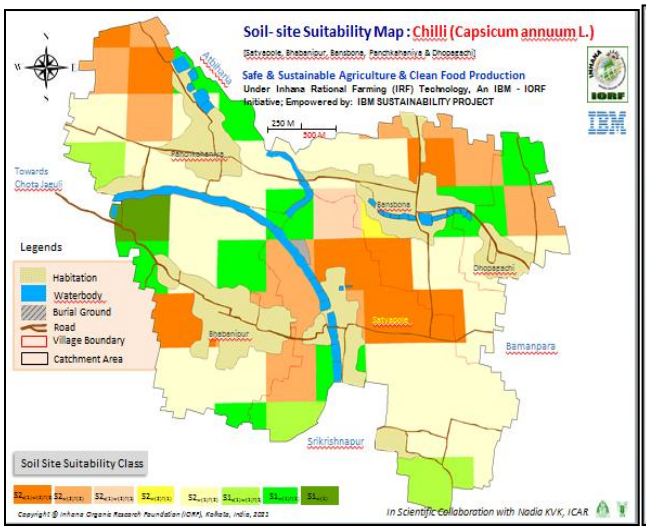
MILESTONE NO. 2 - SUMMARY

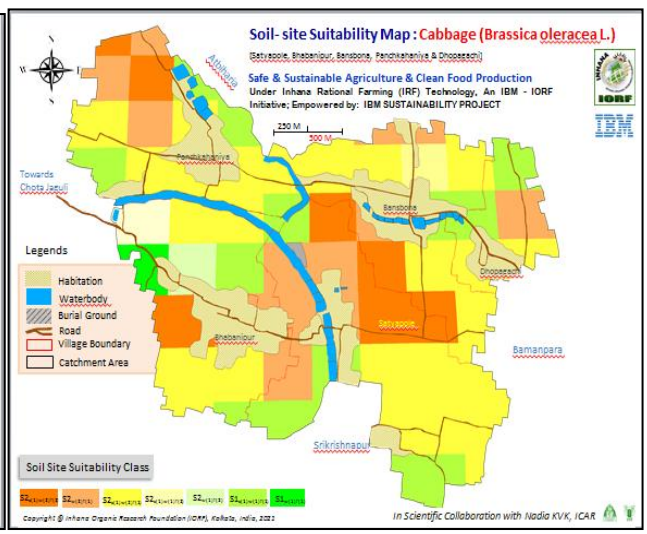
Soil-site suitability of major crops viz., wet season paddy, potato, cabbage, chilli, tomato, carrot, beans, onion, green peas, banana, guava and papaya were evaluated in the study area on a 10 ha grid basis. The potential land suitability sub-classes were also determined after considering the improvement measures to correct these limitations (Sys et al. 1991).

A TOTAL OF 12 SOIL- SITE SUITABILITY MAPS HAVE BEEN DEVELOPED



Evaluation revealed that **SOIL FERTILITY** formed the major bottleneck towards crop cultivation especially due to the poor microbial dynamics in soil, leading to improper nutrient mineralization and availability in the soil solution. **Hence, improvement of this aspect can actually promote the suitability aspect of these soils with respect to the presently cultivated crops.**





IBM **Corporate Social Responsibility**

MILESTONE NO. 3

MODEL DEMONSTRATION OF SAFE & SUSTAINABLE 'CLEAN VEGETABLE SEED' PRODUCTION.

IBM **Corporate Social Responsibility**

Which IBM program is this grant for?

Other

Target Reporting Date

12/16/2022

Milestone Name

Model demonstration of Safe & Sustainable 'Clean Vegetable Seed' production.

Milestone Goal

The seeds developed under conventional farming are generally high fertilizer responsive hence; lack the quality traits that are required for sustaining crop yields irrespective of the changing climatic patterns. The objective is to demonstrate/ develop 'Clean Seed' without any Crop Loss or increasing the Cost of Production to generate better progression towards Sustainable Agriculture

Describe the expected progress toward the goal by this target reporting date.

"Expecting 100 percent achievement of this Milestone by the target date"

Expected progress toward milestone goal, as a number

100

Expected Progress Units

Clean Vegetable Seed

MILESTONE NO. 3 - SUMMARY

Safe and Sustainable Crop Production has become emergent looking at the crop vulnerability and the increasing risk of food chain toxicity. The risk increases under the existential climate change and there has been no solution under conventional farming that can help mitigate the issue while enabling safe and sustainable crop production. Shifting over from conventional farming to nature friendly sustainable practice is also not easy and needs great effort, from suitable technological intervention to efficient resource utilization.

However, the most important thing to start with is 'Quality Seeds' which are suited to perform under low input environment and possess great resilience towards biotic and abiotic stress factors. Furthermore, adaptation is the key to achieving resilience in our food and agricultural system. Adapting seed to changing climates, resource availability, and environmental conditions is one way to mitigate risks for farmers and the food supply they serve.

It is estimated that more than 95% of organic/ low input agriculture is dependent on seeds varieties that were bred for the conventional high input sector**. Recent findings have sown that such varieties lack important traits required under organic and low– input production system, which have major importance towards climate change mitigation strategies** (van Bueren, 2011).

Moreover, vegetable crops are highly sensitive to climatic vagaries, where sudden rise in temperature or irregular precipitation at any phase of crop cycle can affect growth, flowering, pollination and fruit development, which may subsequently lower the crop yield (Afroza et al., 2010). In respect of vegetable seeds, only 50% of the national demand is met by domestic production (Shrestha and Dhakal, 2020). Although vegetable production in India has increased (187.47 mt) with time but shrinking land resources (10.43 mha) and increasing environmental challenges have made the development and use of quality seeds more important (NHB 2018-19, 1st advance estimate) for sustainable vegetable production.

In this background, a Program was undertaken in Phase II Project to develop **'NET ZERO' Clean Vegetable Seeds** through the adoption of Inhana Rational Farming (IRF) Technology – A Comprehensive Organic Technology for Safe and Sustainable Crop Production.

Contd. . .

MILESTONE NO. 3 - SUMMARY

Contd. . .

But the significance of this initiative was that Vegetable Seed Production was done with '**Complete Elimination of Pesticides and 100% Reduction of N-fertilizers**' following **COMPLETE ORGANIC MANAGEMENT** (through Inhana Plant Health Management and utilization of Waste bio-converted Novcom Compost for Inhana Soil Health Management).

Crop		Clean Food 'NET ZERO' Yield (Tonne/ ha)	'NET ZERO' Clean Seed Yield (Tonne/ ha)
BRINJAL	:	29.12	Process Ongoing
CHILLI	:	18.28	Process Ongoing
OKRA	:	17.90	1.278
TOMATO	:	32.09	0.214
GREEN PEAS	:	10.52	0.272
CAULIFLOWER	:	30.24	Process Ongoing
CARROT	:	12.96	Process Ongoing
RED AMARANTH	:	16.20	1.62
CABBAGE	:	22.22	Process Ongoing
BEANS	:	16.42	5.255
SPINACH	:	36.18	3.618
ONION	:	9.80	Process Ongoing
MUSTARD	:	0.528	0.528

HIGHLIGHT

The 'Net Zero' Clean Vegetable Seeds were Produced under Complete Organic Management, in the farmers' field, without any specific seclusion from the surrounding fields and still without increasing the cost of production – A STUPENDOUS ACHIEVEMENT, considering that production of Vegetable Seeds under Conventional Practice is a Cost Intensive Affair primarily considering the Longer residence time in the field, and Higher Pest/ Disease Incidence.

IBM **Corporate Social Responsibility**

MILESTONE NO. 4

DEVELOPMENT OF SUSTAINABLE IMPACT STORIES RELATED TO IBM SUSTAINABILITY PROJECT.

IBM **Corporate Social Responsibility**

Which IBM program is this grant for?

Other

Target Reporting Date

12/23/2022

Milestone Name

Development of Sustainable Impact Stories related to IBM Sustainability Accelerator.

Milestone Goal

To create awareness regarding the 'Clean Food' Program- a definite pathway for Safe and Sustainable Agriculture especially concerning the Statement of the UN "It is currently not clear or well defined what constitutes productive and sustainable agricultural practice" as well as to bring forth the program's impact area w.r.t. SDG-2, 12 and 13; through the various social platforms.

Describe the expected progress toward the goal by this target reporting date.

"Expecting 100 percent achievement of the Milestone by the target date"

Expected progress toward milestone goal, as a number

100

Expected Progress Units

Sustainable Impact Stories

MILESTONE NO. 4 - SUMMARY

This Milestone Highlighted the **'Clean Food' Model and the transformation journey towards Clean Food 'NET ZERO' Model development**

Today we need HIGHER FOOD PRODUCTION FROM LESSER LAND AREA WHILE REDUCING/ ELIMINATING THE USE OF UNSUSTAINABLE/ NON RENEWABLE INPUTS. Hence, the situation demands a **TRANSFORMATIVE CHANGE** in Agricultural Practices to ensure **SUSTAINED production and availability of Safe Food for the rising global population while Mitigating Climate Change Impact** (*The Future of Food and Agriculture- Trends and Challenges, FAO-2017*).

Sustainable agriculture that integrates three main goals i.e., environmental health, economic profitability, and social equity is the only solution especially for a country like India with 224.3 million undernourished people. But the **CHALLENGE** is exhibited by UN's own Statement "**It is currently not clear or well defined what constitutes productive and Sustainable Agricultural Practice**".

The relevance of Sustainable Agriculture increases multifold in the **Indian context** where **more than 90% farmers are marginal and resource poor, with a land holding less than 0.38 hec**. Moreover, any disruption in their livelihood can destabilize the very fundamental base of our food production system, considering that these farmers contribute **51 per cent of total agricultural output and 70 per cent of high value crops** (TOI, 2nd Sept. 2022).

This was the background behind 'Clean Food' initiative of IORF, to enable Farmers' Access to an Effective, Economically Viable and a Conveniently Adoptable Crop Technology that can ensure Elimination of Chemical Pesticides from the crop production system with No Crop Loss and No Hike in the Cost of Production, leading to Safe and Sustainable 'Clean Food' production - SAFE FOR HUMAN HEALTH, SUSTAINABLE FOR ALL.

This IBM-IORF Sustainability Project in the **Nadia District of West Bengal** is a **First of a Kind and the Largest 'Clean Food' Program for Pesticide Free - Pure Food Production in India** encompassing 100 ha area and about 400 marginal and small farmers; that has demonstrated '**Clean Food' (Vegetables) development - SAFE FOR HUMAN HEALTH**

contd...

MILESTONE NO. 4 - SUMMARY

Apart from Chemical Pesticides, chemical fertilizers especially N- Fertilizers form the **other major unsustainable component** of conventional food production. However, **reduction/ elimination of N- Fertilizer Without Crop Loss** is practically possible only through application of Quality Compost in soil. But; the acute scarcity of raw material for on- farm compost production, especially in respect of marginal and small land holders; forms the primary bottleneck towards the objective.

WASTE of any type especially landfill/ legacy waste/ MSW, etc., perfectly fits the bill, also because these are abundant resources and economic option. But apparently there is **dearth of Environmentally Safe and Economically Viable Composting Technology/ ies that can transform these Toxic, especially METHANE EMIITING pollutants** into Safe and mature Compost, suitable for agricultural use.

The Novcom Composting Technology of IORF successfully enabled the bio-conversion of Landfill Waste to provide an **adoptable solution to these resource poor farmers towards on- farm compost production.** Most importantly, bio-conversion of WASTE and application of waste bio- converted Novcom compost in soil rendered **Three Way GHG Mitigation** – i) METHANE Mitigation from source (Landfill Waste) during waste bioconversion, ii) NITROUS OXIDE Abatement due to elimination of N- Fertilizers enabled by application of compost in soil and iii) the related Soil- C Sequestration.

This insight actually led to the development of Clean Food 'Net Zero" (CFNZ) Model.

CFNZ is a first of a Kind **CLIMATE ACTION (SDG-13) MODEL in Agriculture** that will actually deliver **SAFEST FOOD –** Safe for Human Health, Soil & Environment.

A switch over from Conventional Farmers' Practice to Clean Food 'NET ZERO' Model, can totally transform the present GHG Emitting agriculture to a **GHG Sink Agriculture**; as depicted by the **GHG Mitigation Potential of more than 500 MT CO_2 eq. (case specific) per ha of CFNZ production.**

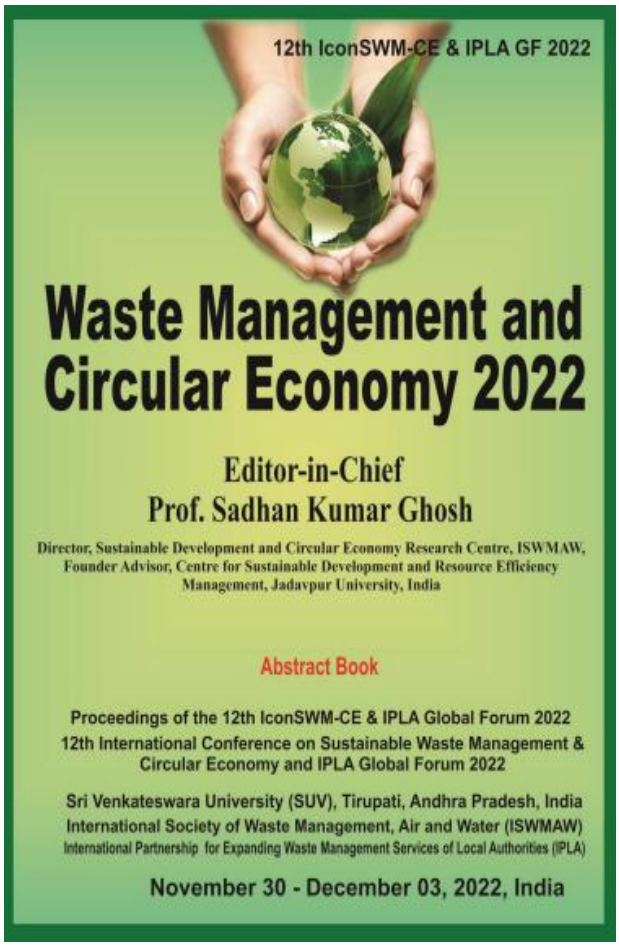
This Climate Action (**SDG-13**) Model attends the Most Critical Area of Sustainability- **SDG 2. But** it is also the **Model for Degraded Soil Reclamation** with clear impact area w.r.t. **SDG-15,** and impacts **4 other Crucial SDGs** i.e., **SDG-1**, **SDG-3, SDG-11** and **SDG-12**.

IBM **Corporate Social Responsibility**

MILESTONE NO. 5

Research Publications based on specific scientific outcomes

MILESTONE NO. 5 - SUMMARY



Three Research Articles were published :

1. **Induction of Novcom Composting Technology for Highest GHG Mitigation under 'Waste to Wealth Program'– A Case Study from IBM-IORF Sustainability Accelerator Project, West Bengal, India.**
2. **Technological breakthrough for large scale bioconversion of coir pith, a highly soil and water polluting material, huge GHG emitter with a very high GWP value, towards development of an effective GHG Offsetting Model.**

3. Establishment of an Innovative Model for Safe & Effective management of Landfill Waste that can Generate Sustainability Imprints in Agriculture, Ecology & Economics – A Barometer for Circular Economy.

These Research Articles highlighted the Impact of Climate Change on Food Production, the Agriculture sector being the second largest contributor of GHGs and also the only sector that can serve as a potential sink of GHG's, where an effective 'Waste to Wealth' program can play a crucial strategic role.

The articles highlighted the Very High GHG Mitigation Potential under Novcom Composting Technology– 17 times Lower value as compared to any Standard Composting Process (200 kg CO_2 eq/ ton wet raw material), **which became 31 times Lower, when Landfill Waste like Coir pith bio- conversion is done under this process. Another crucial finding was >99.0% Abatement of Methane from Source Point under Novcom Composting Technology.**

IBM **Corporate Social Responsibility**

MILESTONE NO. 6

Model demonstration of Safe & Sustainable ‘Clean Paddy Seed’ production.

MILESTONE NO. 6 - SUMMARY

RICE production system is one of the most climate change sensitive agro-ecosystems, which faces huge threat of crop loss under any drastic fluctuation in the weather pattern. In West Bengal almost half of the arable land is under rice cultivation. Moreover, the major rice is grown during the Kharif (rainy) season and is majorly affected by weather fluctuations.

The most important reason why this crop was selected for 'NET ZERO' Clean Seed production is because it is also **one of the most CHALLENGING crops w.r.t. climate change mitigation considering the HIGH WATER and NITROGEN USAGE and HIGH GHG EMISSION POTENTIAL.**

'NET ZERO' CLEAN PADDY SEED grown under **COMPLETE ORGANIC MANAGEMENT** utilizing Inhana Rational Farming (IRF) Technology

The average yield of 4021 kg/ ha obtained under **'NZ' Clean Paddy Seed program** exclusively demonstrated the relevance of **Inhana Plant Health Management** towards not only yield sustenance, rather yield improvement, especially significant, because this was obtained overcoming the extreme climatic events that occurred during the tillering and seed setting phase.

Evaluation of seed quality as per the Indian Seed Certification Standards indicated a Germination Rate of 92% on an average, indicating a high seed viability. Study related to Germination under water stress and salt stress also pointed out the higher resilience of NZ Clean Paddy Seeds towards abiotic stress factor; in comparison to conventional seeds.

QUALITY (RESILIENT) SEEDS are the primary requirement for **SAFE & SUSTAINABLE AGRICULTURE**. In this respect the Seed Vigour Test that defines seed ability to germinate and establish seedlings rapidly, uniformly, and robustly across diverse environmental conditions; forms a crucial indicator. The test results conclusively indicate **'NZ' Clean Paddy Seeds** (*developed under IRF technology*), **as 'High Vigour' seeds, which indicates their potential to enhance the critical and yield-defining stage of crop establishment** - the primary objective of Safe & Sustainable Agriculture.

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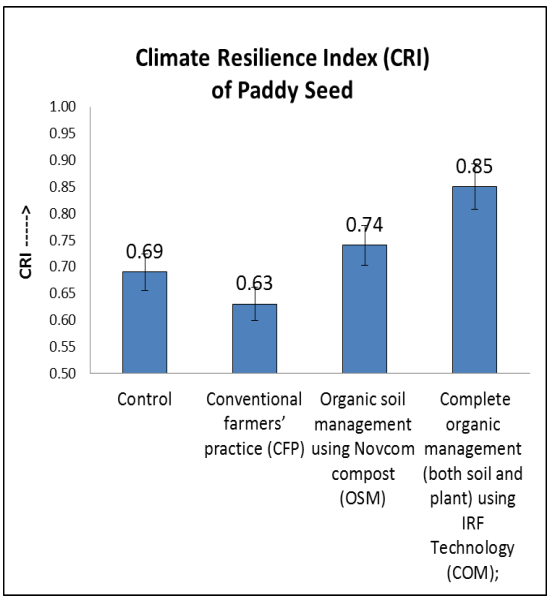
MILESTONE NO. 6 - SUMMARY

"CLIMATE RESILIENCE INDEX (CRI)"



"Climate resilience index (CRI)" which was developed majorly as a function of seed germination under abiotic stress, showed 35.5% and 14.6% higher value in case of the 'NZ' Clean Paddy seeds (COM) as compared to CFP and OSM respectively. The overall better performance of 'NZ' Clean Paddy seeds critically indicates that **the concept of "feed the soil" for sustainable organic farming does not hold true till focus is generated towards "PLANT HEALTH MANAGEMENT".**

ATTRIBUTES OF 'NET ZERO' CLEAN PADDY SEEDS

- ✓ **Climate Resilient Seed**
- ✓ **ZERO CO_2 Footprint Seed**
- ✓ **Zero Pesticide Foot print Seed**
- ✓ **Seed with Zero Seed borne Diseases**
- ✓ **Seed with Higher Germination Potential**
- ✓ **Biotic & Abiotic Stress Resistant Seed**
- ✓ **Seed with Higher Nutrient Utilization Potential**
- ✓ **Seed with 25% Lower Requirement than conventional seeds**

The **'NET ZERO' Clean Paddy Seeds developed under West Bengal Project** was provided to the **Project Farmers of Phase-II, IBM-IORF Sustainability Project at Mandya (Karnataka)** and it is for the **First Time in the Indian Agricultural Scenario that Safe & Sustainable 'Climate Resilient' Seeds has been used for Safe and Sustainable 'NET ZERO' Clean Paddy production through the utilization of Novcom Coir-pith Compost.**

The initiative is also significant considering that a **MAJOR OBJECTIVE** is to test the **CLIMATE RESILIENCE OF THESE SEEDS** in a completely different agro-ecological setting; and to **TRANSFORM** the production scenario from **COARSE GRAIN TO FINE GRAIN VARIETY**.

IBM **Corporate Social Responsibility**

MILESTONE NO. 7

Estimation of Energy Use Efficiency

MILESTONE NO. 7 - SUMMARY

Efficient use of energy in agriculture is crucial for minimization of the environmental problems, to prevent destruction of natural resources and promote sustainable agriculture as economical production system

But the major Challenges for Energy Transition in agri-food systems is to decouple the use of fossil fuels in food-system transformation and related innovations **WITHOUT COMPROMISING FOOD SECURITY.** With the growing demand for energy and food, the transformation of both systems is necessary to align them more closely with global climate and sustainability goals. **In particular, the energy transition can directly affect and be affected by changes in food systems – and vice versa** *(Source: Renewable energy for agri-food systems, 2021 by IRENA and the FAO, UN).*

In this aspect, Energy Analysis of agricultural ecosystems is a concrete approach to investigate and **assess Energy Use Efficiency, and evaluate the SUSTAINABILITY QUOTIENT Of any Crop Production System**.

Assessment of energy requirements of different crop sequences were done in Model Farm under different levels of 'Clean Food' Program which are as given below :

i) 'Clean Food' Program with 100% Reduction of Chemical Pesticides.

ii) 'Clean Food' Program with 100% Reduction of Chemical Pesticides and **50% Reduction of N- fertilizer.**

iii) 'Clean Food' Program with 100% Reduction of Chemical Pesticides and **100% Reduction of N- fertilizer.**

The data obtained was compared with the energy use under Conventional Farming System. **The Evaluation was done w.r.t. Eleven different Cropping Sequences followed in the project area** *viz*., Tomato-Cucumber-Coriander, Potato-Brinjal-Cauliflower, Potato-Okra-Cabbage, Brinjal-Frenchbean-Spinach, Pumpkin-Okra-Cabbage, Brinjal-Carrot, French bean-Okra- Onion, Potato- Chilli-Carrot, Tomato-Ridge gourd- Spinach, Peas -Yam –Cabbage and Pointed Gourd – Cauliflower.

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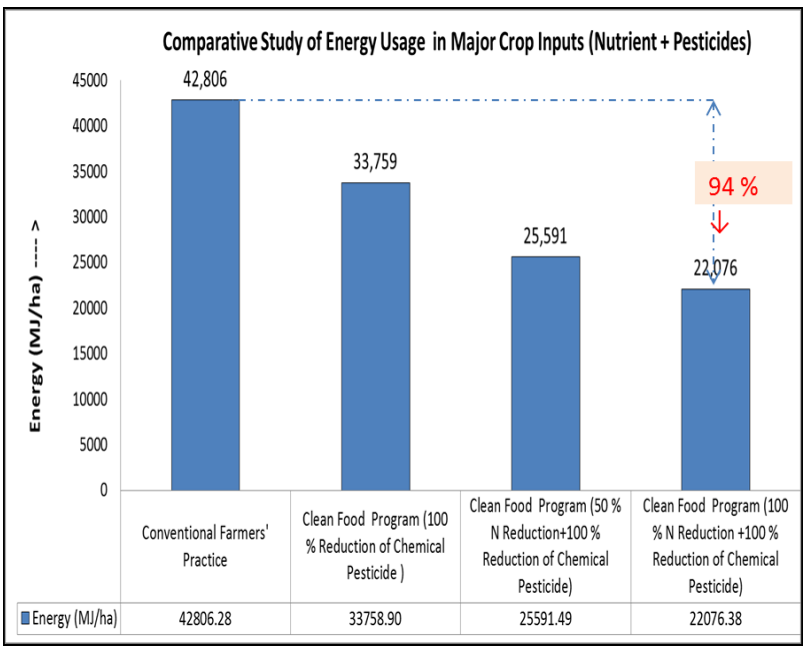
MILESTONE NO. 7 - SUMMARY

27 to 57% higher Energy Output was recorded under the different levels of 'Clean Food' Program, which **indicates higher resilience of this Crop Production Model in terms of ensuring Crop and Economic Security** both in the present and future.

Especially the **highest Energy Output (57%)** under 'Clean Food' program with 100% Reduction of both Chemical Pesticides and N- fertilizers, indicates that these are the primary hands of unsustainability, and when eliminated **can reduce not only the adverse effects on climate, but also mitigate the economic vulnerability of the resource poor marginal and small farmers.**

Also, a **137 percent increase in Nutrient Energy Ratio recorded under the different cropping sequences under 'Clean Food' Model with 100% N- fertilizer Reduction + 100 % Reduction of Chemical Pesticides, highlighted better nutrient utilization efficiency and higher crop response per unit nutrient application, under IRF Technology.**



The **ENERGY INVESTMENT lowered by a remarkable 94%** when both chemical pesticides and N- fertilizers were completely eliminated through the interventional Soil Health Management and Plant Health Management under IRF Technology.

As well as **HIGHER INCORPORATION of RENEWABLE ENERGY SOURCES.**

These 'Clean food' Models demonstrated significant **ENERGY TRANSTITION**, **most importantly WHILE SUSTAINING CROP YIELDS & IMPROVING ENERGY PRODUCTIVITY –** which is a benchmark criteria for SUSTAINABLE AGRICULTURE.

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MILESTONE NO. 8

ESTIMATION OF CARBON SAVING AND GHG MITIGATION

MILESTONE NO. 8 - SUMMARY

The increasing risk of disruption in crop production due to climate change impact throws a major challenge towards mitigating global hunger. **The challenge is intensified by agriculture's extreme vulnerability to climate change. But agriculture is also the second largest contributor of greenhouse gases (GHG). At the same time this is the only sector that can enable both GHG mitigation and adaptation due to its potential to STORE A VAST AMOUNT OF SOIL CARBON -** up to 1 billion metric tons per year, which would offset around 10% of the annual GHG emissions of 8–10 billion metric tons/ year.

Increasing the amount of carbon in soil also makes it more productive for farmers which can only be through SUSTAINABLE FARMING APPROACHES. And for any sustainable farming, AMELIORATION OF SOIL is the most important criteria and QUALITY MANURE, rich in self-generated microflora is prerequisite for ensuring time bound effectiveness irrespective of agro-ecological settings.

EFFECTIVE TECHNOLOGY is the primary requirement towards effective bio-conversion of bio-resources, especially hard to biodegrade waste into quality manure and for GHG offsetting under the composting process, towards making meaningful contribution in respect of climate change mitigation. In this aspect, Analysis of GHG mitigation potential of agricultural ecosystems is a concrete approach to investigate and **assess carbon saving, and to evaluate the SUSTAINABILITY QUOTIENT of any Crop Production System**.

Assessment of GHG Mitigation under **Eleven different Cropping Sequences** was done in the Model Farm under different levels of 'Clean Food' Program which are as given below :

i) 'Clean Food' Program with 100% Reduction of Chemical Pesticides.

ii) 'Clean Food' Program with 100% Reduction of Chemical Pesticides and **50% Reduction of N- fertilizer.**

iii) 'Clean Food' Program with 100% Reduction of Chemical Pesticides and **100% Reduction of N- fertilizer.**

The data obtained was compared with the GHG emission under Conventional Farming System.

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MILESTONE NO. 8 - SUMMARY

Assessment indicates that about 18-20 % reduction in GHG emission can be achieved with COMPLETE ELIMINATION OF CHEMICAL PESTICIDES. The finding substantiated the fact that N-FERTILIZERS ARE THE MAJOR GHG CONTRIBUTORS under the conventional farmers' practice.

The Average GHG emission was **(+) 0.12** kg CO_2-eq/kg produce under Conventionally Managed crop sequence.

In contrast, (-)0.05 kg CO_2-eq and (-)0.19 CO_2-eq per kg produce or a **NET MITIGATION of (-)0.17 to (-)0.31 kg CO_2-eq per kg produce**, was obtained under **CLEAN FOOD MODELS** with 50 % N-Fertilizer Reduction+ 100 % Reduction of Chemical Pesticides; and 100 % Reduction of both N-Fertilizer and Chemical Pesticides; respectively**.**

Comparative study of GHG Emission under Conventional Farmers' Practice *vs*. the GHG mitigation potential under the different 'Clean Food' Models under the Phase-II Project once again substantiated that, **a progression towards Safe and Sustainable Agriculture especially complete elimination of both the hands of unsustainability i.e. the N-fertilizers and Chemical Pesticides** can totally transform agriculture from a GHG Emitting Source to a CARBON Guzzling Sink.

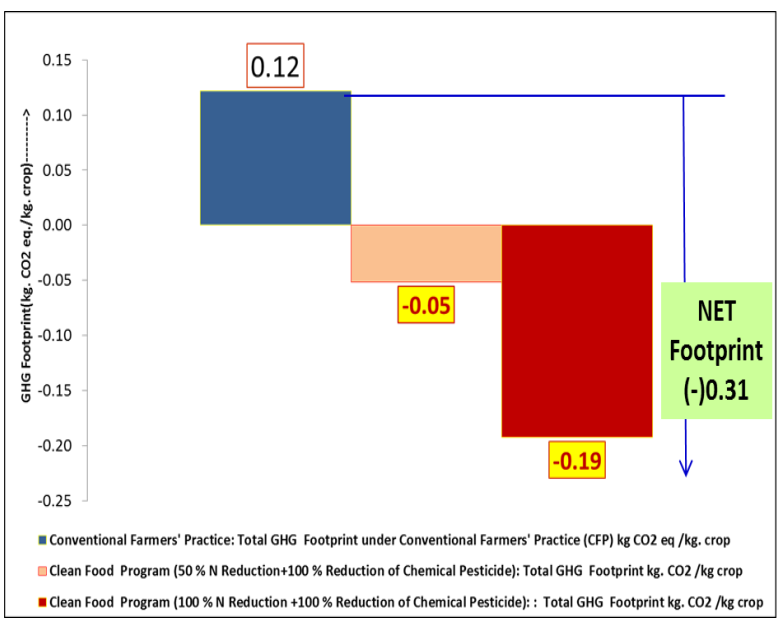

Fig. : Avg. GHG Footprint (kg CO_2 eq/ kg. crop) **under Conventional Farmers' Practice (CFP) vs. 'Clean Food' Models with 50% N Reduction + 100% Reduction of Chemical Pesticide vs. 100 % Reduction of both N- fertilizer and Chemical Pesticide.**

IBM **Corporate Social Responsibility**

MILESTONE NO. 9

ANALYSIS OF SAFETY, QUALITY & SEED RESILIENCE OF CLEAN PADDY & VEGETABLE SEEDS

MILESTONE NO. 9 - SUMMARY

Climate change is threatening food security round the globe, where a large proportion of food is produced by the vulnerable smallholder farmers. The climate change impact has increased the relevance of using quality seeds by many folds; considering that seed quality plays significant role in success/ failure of any cropping system. Climate-resilient crops and crop varieties have been recommended as a way for farmers to cope with or adapt to climate change, but availability of climate resilient vegetable seeds are rare in India if not totally unavailable.

In the present study under IBM-IORF Sustainability Project, a program was initiated towards development of **CLIMATE RESILIENT- Net Zero Clean Vegetable Seeds** in farmers' field under Complete Organic Management with adoption of Inhana Rational Farming (IRF) Technology.

12 different open pollinated vegetable varieties viz. Brinjal, Chilli, Okra, Tomato, Green peas, Cauliflower, Carrot, Red amaranth, Cabbage, French bean, Spinach, Potato and one oilseed variety- Mustard; were selected for the seed developmental program.

Till the time of this report, complete documentation of the seed yield data has been done for eight vegetables varieties *viz.* Okra (1278 kg/ha), Tomato (214 kg/ha), Green peas (272 kg/ha), Red amaranth (1620 kg/ha), Spinach (3618 kg/ha), Bean (5255 kg/ha) and Potato (29.49 ton), as well as oilseed variety mustard (528 kg). Seed quality in terms of germination, seed vigour and climate resilience are in the process which will be documented in the 3rd year activity report.

Initiative was taken up to develop **'NET ZERO' Clean Paddy Seed, considering that Rice is both a Victim and a Cause of Climate Change.** The crop faces many **CHALLENGES** such as declining or stagnant yields, lack of water availability, contamination of natural resources due to excessive use of agrochemicals, biodiversity losses, greenhouse gas emissions and losses due to extreme climatic events.

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MILESTONE NO. 9 - SUMMARY

Quality evaluation of the Net Zero Clean Paddy (NZCP) Seeds paddy seeds was also undertaken to assess the impact of IRF Technology towards the Seed Quality attributes.

SEED QUALITY	Indian Seed Certification Standards for each Class		'Net Zero' Clean Paddy Seed developed under IRF Technology
	Foundation	Certified	Miniket (IET- 4786)
Pure seed (min.)	98.0%	98.0%	**99.85 %**
Inert matter (max.)	2.0%	2.0%	**0.15 %**
Huskless seeds (max.)	2.0%	2.0%	**No**
Other crop seeds (max.)	10/kg	20/kg	**No**
Total Weed seeds (max.)	10/kg	20/kg	**No**
Germination (min.)	80%	80%	**92 %**
Moisture (max.)	13.0%	13.0%	**9.32**

The germination rate of NZCP seeds was found to be 92% on an average, indicating a high seed viability. Germination Potential of NZCP Seeds was found to reduce considerably under water stress and salt stress, but the reduction was significantly lower as compared to conventional seeds; **which indicated their higher resilience to un-favourable conditions**. In terms of Germination under Accelerated Ageing **(G_{AA})**, the **'NZ' Clean Paddy Seeds showed superior performance as compared to the conventional seeds.**

Studies indicate that membrane lipid peroxidation is one of the major causes of seed ageing under accelerated ageing conditions (Oliveira et al., 2011a). However, **healthy plants contain numerous antioxidant compounds, both enzymatic and non-enzymatic, which act to prevent oxidative damage by the scavenging free radicals** before they attack membranes or other seed components (Bhaskaran and Panneerselvam, 2013). **The G_{AA} test values confirmed that the 'NZ' Clean Paddy Seeds embodied the potentials of a 'Healthy Plant'.**

IBM Corporate Social Responsibility

MILESTONE NO. 10

SAFETY AUTHENTICATION OF 'CLEAN FOOD' THROUGH 'FOOD SAFETY ASSESSMENT TOOL'

MILESTONE NO. 10 - SUMMARY

The **World Health Organization (WHO) states** "**If it is not safe, it is not food", as it does not serve its purpose to provide proper and safe nutrition**".

And now under the existential Climate Change, **the FAO indicates**, 'For the world's poor, adapting to climate change and ensuring food security go hand in hand and thus a paradigm shift towards agriculture and food systems that are more resilient, more productive, and more sustainable is required. **Food security requires SUFFICIENT, AFFORDABLE, NUTRITIOUS, & SAFE FOOD.**

According to the FSSAI report 2019 (Mittal, 2019), among the vegetable samples studied **brinjal showed the maximum number of pesticide residues; followed by the samples of tomato, okra, cabbage, cauliflower and cucumber.**

According to Food Safety and Standards (Contaminants, Toxins And Residues) Regulations, 2011; developed by Food Safety and Standards Authority of India, **lowest limits of pesticide residue in vegetables is 0.1 ppm except very few cases**. This was in accordance with Codex Alimentarius Maximum Residual Limit (0.1 ppm) in case of vegetables.

The Phase-1 of Project Demonstrated the 'CLEAN FOOD' MODEL- SAFE for Human Health @ Same Cost, Hence Sustainable for All - **aligned with SDG-2, that can be Adopted across Agro-ecological Zones and variable Farm Economies.**

Moreover, Clean Food means Safety Authentication NOT BY AUDIT but through ACTUAL ANALYSIS. The chromatographic technique for residue analysis however, is hugely expensive, complex, time-consuming and require specific resources and infrastructure which offer major hindrance towards regular analysis for monitoring of food safety. Especially for a country like India, with absolute dominance of marginal farmers in vegetable cultivation, lack of awareness, resource scarcity, inability to take economic risk and flaws in maintaining the standard practices w.r.t. chemical usage; enhances the availability of pesticides in food product.

Moreover the short time gap between the field harvest of vegetables and consumption, limits the scope for safety analysis even if the infrastructure and economics is not considered.

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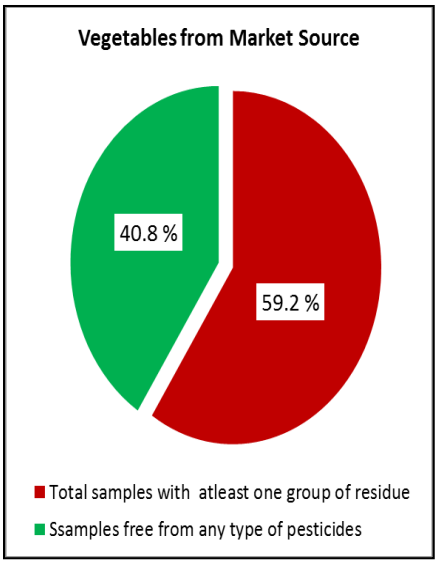
MILESTONE NO. 10 - SUMMARY

In this background an effective, speedy, yet an affordable method was needed to enable pesticide residue analysis in situations of limited resources, more so for safety authentication of Clean Food.

In this respect the **Colorimetric Assay Test** was identified as a solution that can tick off all the requirements. The Colorimetric Pesticide Assay Test can serve as the **MOST STRINGENT TEST** for Food Safety, due to the scope for detection of the Collective Presence/ Absence of the Pesticide Residues up to the Lowest- Group Specific Permissible Limits. **And Most Importantly at just 1/10th of the Conventional Cost of Residue Analysis.**



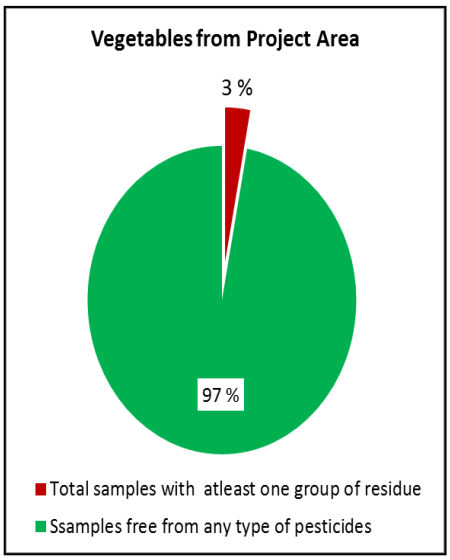


Fig. Showing Percent Vegetable Samples that exceeded Maximum Residue Limit (MRL) w.r.t. at least one pesticide group, as per CODEX ALIMENTARIUS FAO-WHO & FSSAI (>0.10 ppm) Standards

Pesticide Residue analysis of more than **140 vegetable samples** representing **18 different varieties of vegetables**, indicated **Residue Free Status in 97% of the samples collected from the 'Clean Food' Project Area.**

Another crucial finding was made in case of crops like **brinjal and pointed gourd**, which have a higher pesticide load **because of long duration (7-8 months) in field**. Under 'Clean Food' Program with adoption of IRF Technology, a **considerable reduction of pest pressure was observed even in case of these crops, which naturally lowered the requirement for pesticide application.**

Analysis also revealed **92.6% Reduction in the Risk of Pesticide Contamination in Food under 'Clean Food' Program, especially through the intervention of Plant Health Management under IRF Technology**.