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Building Regenerative Agri-Net Zero Model: Bridging Corporate Responsibility and Farmers' Sustainability through Climate Action Strategies

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Abstract

Climate change is accelerating threats to global food and nutritional security, placing unprecedented strain on livelihoods of farming community. Intensifying biotic and abiotic stress are undermining crop productivity, while the soaring costs of cultivation compound the vulnerability of small and marginal farmers—the backbone of the agricultural workforce. Despite widespread recognition of these challenges, scalable, ecosystem-aligned technological interventions that are socially acceptable and economically viable remain elusive. Agri-Net Zero is a top climate action strategy that transforms agricultural landscapes into dynamic carbon sinks while directly reducing greenhouse gas emissions. By integrating regenerative practices with economic and social benefits, it not only drives net zero compliance but also enhances ecosystem resilience and rural livelihoods.

In response, the IBM-IORF Sustainability Accelerator initiative has piloted a climate-resilient Agri-Net Zero model across two agro-ecosystems in India by integrating Inhana Rational Farming (IRF)—a nature-based, regenerative farming framework. IRF eliminates chemical pesticide use, minimizes N fertilizer inputs, restores soil health and enhances plant resilience through targeted physiological interventions .

The outcomes of regenerative, coconut-based integrated farming systems are transformative: a 30% increase in crop yield, 20% improvement in nutrient use efficiency, up to a 60% transition to renewable energy use, 40% boost in farm income, 17% growth in rural employment, and carbon mitigation potential of up to 250 metric tons of CO_2e per hectare. These results, independently verified through third-party audit, led to India's first Agri-Net Zero certification by iNoCarbon, UK. Crucially, innovations such as coir pith recycling and nitrogen input optimization simultaneously advance soil carbon sequestration and reduce greenhouse gas emissions. This model presents a compelling case forcorporate Net Zero ambitions with the sustainability of farming communities, delivering measurable social and environmental co-benefits while directly addressing seven crucial UN Sustainable Development Goals (SDGs). Strategic investment in such regenerative transitions can empower farmers as pivotal actors in the global response to climate change.

Key Words : GHG mitigation, Soil health management, ACFA (version 2.0)

Introduction

Climate change is intensifying biotic and abiotic stresses on agriculture, directly threatening global food and nutritional security (Benitez-Alfonso et al., 2023). These escalating stresses reduce crop productivity and inflate cultivation costs, making climate-resilient, regenerative agricultural practices not only urgent but essential for future food systems (WEF, 2024). These practices—centered on soil and plant health—are key to adapting to climate shocks and mitigating their long-term impacts (Bera et al., 2025). However, small and marginal farmers—who constitute a majority of the global farming population—remain most vulnerable, lacking access to adaptive resources and technical capacity (Mazik et al., 2025).Simultaneously, the corporate sector faces increasing pressure to embed sustainability into operations to meet Net Zero targets and drive ESG commitments. Globally, nearly 9,000 companies have pledged emission reductions, with ~3,500 targeting net-zero. Europe leads with 2,998 companies; Asia follows with 1,846. The UK tops the list (702 firms), while China—despite being the largest global emitter—lags in corporate adoption. India ranks sixth with 127 companies committed to net-zero (ET Energy World, 2024). Bridging this corporate-agriculture divide is vital for achieving scalable, systemic climate action.

Agri-Net Zero emerges as a leading climate action strategy that transforms agricultural landscapes into dynamic carbon sinks, directly reducing greenhouse gas emissions. This innovative approach leverages regenerative practices to improve soil health and enhance biodiversity, positioning agriculture as a key player in net zero compliance. By integrating these sustainable farming methods, Agri-Net Zero not only mitigates emissions but also unlocks significant economic and social benefits for rural communities. Its comprehensive framework strengthens ecosystem resilience while bolstering rural livelihoods, reinforcing the critical role of agriculture in the broader fight against climate change. Consequently, Agri-Net Zero stands as a transformative strategy, charting a pathway toward a more sustainable and climate-resilient future.

The Regenerative Agri–Net Zero Model offers a transformative pathway, enabling corporations to enhance ESG performance through measurable carbon mitigation alongside social and ecological co-benefits. Yet two persistent gaps hinder progress: the absence of a roadmap for sustainable agriculture, and the challenge of quantifying carbon mitigation, due to the lack of standardized tools tailored to farming (Guan et al., 2023).

For wide-scale success, this model must be climate-resilient, ecosystem-aligned, easily adoptable, financially viable, and scalable. Particularly in India, where over 80% of farmers are smallholders, risk-averse models are crucial. The model must avoid productivity losses while restoring soil–plant–ecosystem balance from the outset. This is achieved through two pillars: (1) a robust bioconversion technology to convert waste into compost—a scalable, low-cost solution for sustainable soil health; and (2) plant health management strategies that ensure smooth transitions from synthetic nitrogen to compost-based systems. Given that abrupt nitrogen reduction often leads to yield loss, targeted plant health practices can safeguard productivity and support nutrient sustainability.

This study documents the development and deployment of the Climate-Smart Agri–Net Zero model, highlighting its dual impact: empowering farmer resilience and accelerating corporate climate goals. It further incorporates ACFA (v2.0)—India's first carbon accounting standard for sustainable agriculture—to address the persistent challenge of carbon measurement (Gomage, 2024). Together, these innovations pave the way for regenerative agricultural transitions that align climate, community, and corporate goals—delivering a viable blueprint for a sustainable, net-zero food future.

Materials and method

Study Area : The study was initiated under IBM-IORF Sustainability Project during 2022-23 at Mandya District, Karnataka, India. The area belongs to hot, moist semiarid agro-ecological sub region 8.2 with medium to deep red loamy soils, low available water holding capacity (AWC) and length of Growing Period 120 – 150 days.

Coir Pith: A Persistent Landfill Hazard, Not Just Agro-Waste

Coir pith—a residue generated from coconut processing—deserves recognition as landfill waste rather than agro-waste due to its inherent recalcitrance and environmental risks. Its high lignin content and markedly imbalanced carbon-to-nitrogen ratio hinder microbial metabolism, resulting in exceedingly slow biodegradation. This persistent nature leads to prolonged accumulation in landfill sites, where coir pith becomes a significant source of methane emissions, a potent greenhouse gas (Rajalakshmi et al., 2018; Brebu & Vasile, 2010). Moreover, coir pith leachates are rich in bioactive compounds such as phenolics and tannins, which can disrupt soil microbial dynamics and nutrient cycling if inadvertently released into the environment (Singh & Patel, 2020; Khan et al., 2011). In light of these complexities and its limited capacity for rapid natural decomposition, coir pith should be reclassified as landfill waste. Such a reclassification would underscore the need for stringent waste management practices and innovative recycling strategies to mitigate its contribution to environmental pollution and methane emissions, aligning regulatory efforts with its true impact on ecological and human health (Kirchherr, Reike, & Hekkert, 2017; FAO, 2018). This new perspective calls for targeted regulatory interventions, as already suggested by agencies in India, including the Central Pollution Control Board and the Tamil Nadu Pollution Control Board, which recognize the severe challenges posed by improperly managed coir pith in landfill settings (CPCB, 2016; TNPCB, 2020; Devanathan, 2021).

Clean Food Net Zero Program: Coconut-Based Circular Economy Model

Under the IBM-IORF Sustainability Project (2021–22 to 2023–24), a comprehensive coconut-based intercropping model was developed to enhance crop diversity and improve farm productivity on marginal soils by integrating Inhana Rational Farming Technology, a nature harnessed complete organic package of practice. This approach repurposes coir pith—traditionally a waste product that contributes to soil and water pollution as well as methane emissions—by subjecting it to Novcom Composting Technology, a process that bio-converts the residue into a safe, stable, and mature compost within 30 days; the resulting product is enriched with native microflora essential for rapid soil microbial regeneration. The Novcom coir pith compost was applied at 40 ton/ha to rehabilitate soils deemed unsuitable for vegetable and other agricultural crops. Post-transplanting, Inhana Plant Health Management solutions were periodically administered according to the recommended schedule, effectively promoting balanced crop growth, enhancing plant immunity, and fortifying defense mechanisms against pests and diseases, thereby reducing pesticide dependency; any minor pest issues that arose were controlled using on-farm neem-based concoctions. Furthermore, the formulation of the Clean Food Net Zero (CFNZ) program was guided by five key criteria: (i) alignment with ecosystem services; (ii) governance by a sustainable agro-technology framework that equally emphasizes soil and plant health management to achieve the program's objectives; (iii) economic viability;

(iv) ease of adoption and social acceptability; and (v) replicability across large landscapes, irrespective of agro-ecological variability and crop choice.

Program undertaken at Mandya, India : Coconut Based Integrated Crop Cultivation towards development of Regenerative Agri-Net Zero Model

Under the IBM-IORF Sustainability Project, an innovative program was undertaken at Mandya to develop coconut-based Regenerative Agri-Net Zero Model by integrating scientific interventions and regenerative farming practices. Three distinct intercrop models were implemented within coconut plantations on marginal red gravelly soils characterized by low fertility and diminished microbial activity—soils traditionally considered unsuitable for nutrient-sensitive, short-duration vegetable crops. Through the elimination of chemical pesticides and nitrogen fertilizers, these lands were transformed into productive fields, thereby illustrating a sustainable, chemical-free approach to modern agriculture. The program was initiated with a comprehensive field and socio-economic survey, followed by grid-wise soil sampling and soil resource mapping, followed by demonstrations of Novcom coir pith composting to valorize coir waste into nutrient-rich compost. Farmers were engaged through meetings designed to develop awareness and impart technical know-how regarding regenerative farming principles, leading to the adoption of Inhana Rational Farming (IRF) Technology. Additionally, a plant health management regime was introduced under the Inhana Plant Health Management (IPHM) program, complemented by integrated pest management strategies utilizing alternate and on-farm concoctions. The circular economy models were rigorously analyzed for their impacts on crop yield, nutrient utilization, soil health, energy consumption, greenhouse gas emissions, and overall cost–benefit ratios—parameters deemed critical for improving the livelihoods of resource-poor farmers. By emphasizing resource efficiency, waste minimization, and the systematic recycling, reusing, and regeneration of resources, this program not only optimized productivity but also reduced environmental impacts, thereby enhancing both the economic prospects and well-being of the farming communities involved.

Inhana Rational Farming Technology

Inhana Rational Farming (IRF) Technology, developed by Dr. Phalguni Das Biswas: pioneer in nature harnessed organic farming technology in India with over 25 years of research experience—provides a nature-receptive pathway for sustainable crop production by harmonizing the interrelated components of the ecosystem. This innovative approach enhances both ecological health and economic sustainability by focusing on two principal objectives: the energization of the soil system to promote its role as an effective growth medium and the energization of the plant system to facilitate optimal nutrient extraction, utilization, and assimilation, as well as to stimulate intrinsic biochemical and structural defenses (Bera et al., 2014). Central to IRF Technology is the use of specially formulated In-House solutions for soil and plant energization. These solutions incorporate technology-specific plants that store the energetic properties of the five basic elements—earth, water, fire, air, and space—as well as the five basic life forces, also known as Prana Shaktis. Selection of these plants is governed by parameters such as sunrise, sunset, seasonal changes, and other critical environmental factors. Their botanical extracts are subsequently potentized and energized following the Element Energy Activation (E.E.A.)® principle, a method that underscores the significance of "Chaitanya Shakti" or the basic life force, which is fundamentally manifested as solar energy.

According to the E.E.A. principle, all living organisms can be likened to complex machines driven by this life force, where two major processes operate continuously: self-nourishment and self-protection. Self-nourishment is supported by the Panchamahabhutas, with earth contributing to nutritional content and structure formation, water facilitating nutrient transport, fire driving metabolism and photosynthesis, air enabling respiration, and space providing the necessary environment for biochemical reactions and plant growth. In contrast, the self-protection mechanism is activated when any imbalance occurs in these vital functions; here, the Prana Shaktis—Apana (governing root function and nutrient extraction), Samana (regulating transpiration), Udana (influencing photosynthesis and enzyme secretion), Prana (controlling respiration), and Vyana (ensuring spatial adequacy for metabolic activities)—collectively work to restore equilibrium. By stimulating these internal life forces rather than relying on external chemical interventions, IRF Technology effectively overcomes plant diseases and pest infestations, ensuring balanced nutrient uptake and improved resilience. This integrative approach, based on precise "Energy Management," tailors solutions to specific crop and agro-climatic conditions, thereby laying the groundwork for sustainable, chemical-free agriculture.

Coir Pith Composting with Novcom Composting Technology

Novcom Composting Technology harnesses the Element Energy Activation (EEA) Principle to create an optimal environment that accelerates microbial self-generation and expedites the biodegradation of coir pith, a byproduct of coconut processing, into high-quality organic compost. This method employs controlled aeration, precise temperature regulation, and effective moisture management to yield a consistent, microbe-rich product that not only improves soil fertility and water retention but also supports sustainable agriculture by reducing waste and curtailing the reliance on chemical fertilizers. In a designated upland, flat area, the process begins with constructing a 10 ft. × 8 ft. × 6 ft. support structure made of bamboo strips and coconut leaves, designed to accommodate an approximate 8–9-ton heap of coir pith compost. The preparation involves applying a basal layer of cow dung slurry on the floor and inner walls of the support structure to establish an initial microbially active base. Coir pith is then mixed with cow dung slurry at an 80:20 weight ratio and layered in increments of approximately 0.5 ft. until the structure is filled, with each layer receiving about 60 ml of Novcom solution—this solution is prepared by diluting 25 ml in 5 liters of water—to facilitate microbial activation. Due to the inevitable compression of the material as it is layered, a total of 16 layers (amounting to about 2000 ml of Novcom solution) is required to reach the final 6-ft. height. After assembly, the compost heap is covered with coconut leaves and left undisturbed for the initial 9 days to promote in situ microbial activity. On the 10th day, one side of the heap is opened and the material is thoroughly mixed using a JCB, and the restructured heap is again treated with 2000 ml of the Novcom solution. This mixing process is repeated on the 20th day to ensure uniform microbial distribution and further acceleration of the composting process. Ultimately, by the 30th day, the composite material transforms into a matured, nutrient-rich compost that reflects the efficacy of the EEA Principle in converting a challenging organic residue into a sustainable agricultural resource, aligning with environmentally conscious waste management practices and the principles of circular economy in agriculture (Bera et al., 2023).

Compost, Soil, Crop Productivity, and Energetics Analysis

In this study, fifty composite samples from distinct Novcom coir pith compost heaps were systematically collected and analyzed for various quality parameters in accordance with the standard methodology described by Seal et al. (2012), with the subsequent calculation of a Compost Quality Index following the protocol of Bera et al. (2013). Soil quality was concurrently assessed by procuring samples from the 0–30 cm depth prior to the initiation of the experiment and again one year later; these samples were subjected to rigorous evaluations of physicochemical properties and fertility parameters based on established methods (Jackson, 1973). Additionally, microbial biomass carbon was quantified using the dichromate oxidation method (Vance et al., 1987), while soil respiration was determined through chemical titration of trapped CO_2, and soil FDAH was measured as per the standard procedures outlined by Haney et al. (2008). Crop productivity was assessed following recognized guidelines (Patrick, 1999) and later converted to coconut equivalent yield, ultimately facilitating the computation of total system productivity using methodologies described by Ghosh et al. (2021) and Naveen Kumar et al. (2017). The energy dynamics of the system were evaluated by calculating metrics such as energy use efficiency, energy productivity, specific energy, energy intensiveness, and net energy, all derived according to the standardized procedures reported by Banaeian et al. (2011). Finally, the overall environmental impact was quantified by determining the system’s carbon footprint using ACFA (version 2.0), a carbon computing standard specifically developed for Indian agriculture by the Inhana Organization Research Foundation (IORF) in collaboration with ICAR-ATARI, Kolkata (Zone-V) and i-NoCarbon Limited (i-NC), UK, based on relevant IPCC guidelines and substantiated by empirical research (IORF, 2024). Together, these comprehensive analyses provide critical insights into the quality of the compost and soil, the efficiency of nutrient and energy use, and the sustainability of crop production systems, thereby supporting the development of best practices for sustainable agricultural management and reducing the environmental impact of farming operations.

Result and discussion

The result and discussion section comprehensively addresses a range of key issues. It begins with an evaluation of Novcom coir pith compost quality and progresses to assess crop performance, nutrient use efficiency, pesticide load, energy transition, farm income, and employment generation. In addition, it examines the impact of the Regenerative Agri-Net Zero Model on soil quality and quantifies greenhouse gas mitigation achieved through the CFNZ program across various crops. The analysis further encompasses the development of the Regenerative Agri-Net Zero Models, presents a multifaceted impact assessment of these models, and critically evaluates the economic viability of sustainable agricultural initiatives.

Analysis of Novcom Coir Pith Compost Quality

A comprehensive investigation into the efficacy of Novcom Composting Technology was conducted through batchwise 30th day samples of Novcom coir pith compost to evaluate its quality as per National and International Standards. Central to this assessment was the measurement of the carbon-to-nitrogen (C:N) ratio, which declined markedly from an initial approximate value of 100:1 in raw coir pith to less than 30:1 by day 30, signifying rapid organic matter degradation. Concomitant with this decline, total nitrogen content increased by approximately 98%, while lignin content experienced an estimated 60% reduction within the same period, confirming substantial biochemical transformation. Correspondingly, organic carbon content reduced from about 51.78% in the untreated material to approximately 27.50% in the mature compost, aligning with the typical range observed in stable compost (16–38%). These chemical transformations were correlated by very high microbial load, with bacterial, fungal, and actinomycete populations reaching the order of 10^{16} c.f.u. per gram of moist compost, which attests to the very intense microbial activity essential for accelerated biodegradation. The breakdown of complex organic compounds through microbial enzymatic processes, under optimal conditions, underscores the efficiency of the technology. Additionally, phytotoxicity bioassay tests confirmed the absence of deleterious compounds in the final compost product and revealed that the amendment actively promotes seed germination and root growth, thereby enhancing its agronomic value. Collectively, these results not only demonstrate significant improvements in physicochemical and biological compost parameters but also illustrate the environmental benefits of the technology, positioning Novcom composting as a robust and sustainable strategy for managing coconut processing residues and enhancing soil fertility while mitigating greenhouse gas emissions.

Table 1 : Physicochemical, nutritional, biological quality parameters and lignin content of Novcom coir pith compost.

Test Parameters	Raw Coir pith	Novcom Coir pith Compost
Physicochemical & Nutritional Quality		
Moisture (%)	65.2 – 78.5	69-2 – 74.1
pH (H_2O)	5.30- 5.21	6.24 – 6.78
EC (dSm^{-1})	3.01 – 3.51	2.13 – 2.68
Organic Carbon (%)	49.6 - 52.4	25.1 – 29.7
Total N (%)	0.43 – 0.61	0.89 – 1.28
Total P_2O_5 (%)	0.06 – 0.17	0.15 – 0.21
Total K_2O (%)	1.31 – 1.78	2.69 – 3.78
C:N	94:1 – 108:1	25:1 – 30.4
Biological Quality		
Bacteria (c.f.u. per gm moist compost)	-	(31 -78) X 10^{16}
Fungi (c.f.u. per gm moist compost)	-	(17 – 34) X 10^{16}
Actinomycetes (c.f.u. per gm moist compost)	-	(7 – 16) X10^{16}
Stability, Maturity & Phytotoxicity Parameters		
CO_2 Evolution Rate ($mgCO_2$–C/g OC/day)	-	1.13 – 1.89
Germination Index (Phytotoxicity Bioassay)	-	0.91 – 1.11
Lignin Degradation Study		
Total lignin %	39.8 - 43.7	21.2 – 24.7

Crop performance, Nutrient Use efficiency, Pesticide Load, Energy Transition, Farm Income, Employment generation under Regenerative Agri-Net Zero Model

Crop productivity of coconut based intercropping under Regenerative Agri-Net Zero Model adopted in Mandya, Karnataka was compared with conventional coconut based intercropping practice. Under IBM-IORF Sustainability project, 3 major coconut based intercropping viz (i) CBCE 1 : Coconut -Millet – Vegetable, (ii) CBCE 2: Coconut - Maize – Vegetable and CBCE 3: Coconut – Ginger was taken under study and comparative assessment was done under Conventional Farmers Practice (CFP) and Clean Food Net Zero (CFNZ) program.

Table 2 : Comparative study of crop performance, nutrient use efficiency, pesticide load, energy productivity, income generation under CFP and CFNZ management

Sl No	Parameters	Coconut-based Integrated Farming Systems					
		CBCE 1		CBCE 2		CBCE 3	
		CFP	CFNZ	CFP	CFNZ	CFP	CFNZ
1	Coconut Equivalent yield	9473	10666	11044	12574	23025	28535
2	System Productivity	14555	16387	16991	19345	35424	43900
3	Nutrient Use Efficiency	35.96	50.94	35.43	53.07	29.61	32.58
4	Nutrient Use Efficiency (based on availability in org. manure)	35.96	84.90	35.43	88.45	29.61	54.30
5	Pesticide Load	0.091	0.00	0.091	0.00	1.371	0.00
6	Crop Pesticide Pollution Index (CPPI)	0.006	0.00	0.006	0.00	0.084	0.00
7	Energy Productivity	0.28	0.94	0.29	0.99	0.24	0.69
8	Farm Income (gross)	562452	634150	568392	642784	328272	347656
9	Employment Generation Potential	125	245	131	251	230	350

Comparative analyses were conducted across three distinct coconut-based integrated crop production systems under two management regimes: Conventional Farmer Practice (CFP) and the Clean Food Net Zero (CFNZ) program. The results revealed that the CFNZ model consistently outperformed the CFP system, with average crop yield increases ranging from 12.6% to 23.9% across various cropping sequences. In addition, when total nutrient inputs (NPK) were provided through organic manure, nutrient use efficiency (NUE) was 33.8% higher under the CFNZ program. Notably, despite the inherent limitation that only about 30% of nitrogen, 60–70% of phosphorus, and 70% of potassium from organic manure are available to the first crop cycle, the overall nutrient uptake was significantly improved in the CFNZ system compared to CFP. This enhancement is largely attributable to the integrated Inhana Plant Health Management approach incorporated in the CFNZ program, which bolsters plant physiological functions, supports growth in low-input environments, and enhances resistance against both biotic and abiotic stresses. Furthermore, improvements in internal plant immunity and enhanced soil–plant–environment interactions were evidenced by a reduction in crop pesticide load, with the pesticide pollution index dropping to zero under CFNZ—a critical indicator for safe food production. Energy productivity also increased dramatically, exhibiting gains between 187% and 247%, which underscores the effectiveness of the nature-harnessed pathways employed in the CFNZ system. Economically, while overall farm income under CFNZ increased by about 10% relative to CFP, a shift to monoculture coconut cultivation has the potential to boost gross income by more than 50%.

Impact of Regenerative Agri-Net Zero Model on Soil Quality

A comparative assessment of soil health under Conventional Farming Practices (CFP) and the Clean Food Net Zero (CFNZ) management revealed significant differences in soil quality improvements. The CFNZ approach, emphasizing regenerative techniques, demonstrated notable enhancements in both physico-chemical and biological soil properties, surpassing the outcomes observed under CFP.

One of the most striking findings was a 25% increase in soil organic carbon (SOC) in CFNZ-managed fields post-intervention, while CFP fields exhibited negligible changes. This elevation in SOC is critical as it enhances soil structure, water retention, and nutrient availability, contributing to overall soil fertility. In terms of nutrient dynamics, both management systems showed improvements in available nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) levels. However, CFNZ fields demonstrated a more balanced nutrient profile, indicative of sustainable nutrient cycling facilitated by regenerative practices.

Table 3 : Comparative study of soil quality parameters

Soil Physico-chemical parameters	pH	EC (1:5) dSm^{-1}	Org. C%	Av NO_3 (ppm)	Av-N	Av P_2O_5	Av. K_2O	Av- SO_4
					< ------------ Kg/ha -------------->			
Before experimentation								
CFP	6.14	0.053	0.50	29.19	168.04	32.43	534.26	424.58
CFNZ	6.15	0.051	0.53	31.02	165.70	30.15	468.90	432.10
Post Experimentation								
CFP	6.15	0.054	0.51	32.10	213.10	32.10	542.10	356.10
CFNZ	6.23	0.059	0.66	28.80	203.25	38.97	505.05	395.54
Soil Biological parameters	**Bacteria**	**Fungi**	**Actino-mycetes**	**MBC[1]**	**FDA[2]**	**SR[3]**	**qMBC[4]**	**qCO_2[5]**
Before experimentation								
CFP	10×10^4	11×10^3	4×10^3	46.70	14.46	0.16	0.93	3.43
CFNZ	12×10^4	9×10^3	6×10^3	45.8	13.2	0.17	0.86	3.71
Post Experimentation								
CFP	16×10^4	9×10^3	6×10^3	45.5	15.10	0.15	0.89	3.30
CFNZ	59×10^5	13×10^4	19×10^3	66.8	19.01	0.21	1.01	3.14

Note : [1]MBC; Microbial biomass carbon (micro gm biomass C/gm dry soil/hr), [2]SR:Soil Respiration, [3]FDA : Soil Fluorescein diacetate hydrolysis activity (µg/gm dry soil), [4]qMBC :Microbial Quotient, [5]qCO_2: Metabolic Quotient

Biological indicators further underscored the efficacy of the CFNZ program. There was a substantial increase in microbial populations, including bacteria, fungi, and actinomycetes, in CFNZ implemented fields. This microbial proliferation is attributed to the application of high-quality Novcom compost at 40 tonnes per hectare, which provides a rich substrate for microbial growth. Enhanced microbial activity was evidenced by increased microbial biomass carbon (MBC) and fluorescein diacetate (FDA) hydrolysis activity, both of which are indicative of a dynamic and healthy soil microbial community. These biological enhancements are vital for nutrient mineralization and overall soil ecosystem functioning.

The comparative analysis clearly indicates that the CFNZ program fosters a more robust and resilient soil environment compared to conventional practices. By improving both chemical and biological soil properties, the CFNZ program not only enhances immediate soil fertility but also contributes to long-term agricultural sustainability. These findings align with broader research indicating that regenerative agricultural practices can significantly improve soil health and productivity.

GHG Mitigation under CFNZ program in different crops

Agriculture occupies a pivotal role in both generating GHG emissions and offering pathways for their mitigation through carbon sequestration. The 25.2-hectare Clean Food Net Zero (CFNZ) program in Mandya, Karnataka, India towards development of Regenerative Agri-Net Zero Model, which employs IRF Technology, exemplifies this dual potential. Through substantial carbon sequestration, notable emissions reductions, and the enhancement of ecosystem health, the CFNZ program illustrates how innovative agricultural practices can lead to net-zero emissions without compromising productivity.

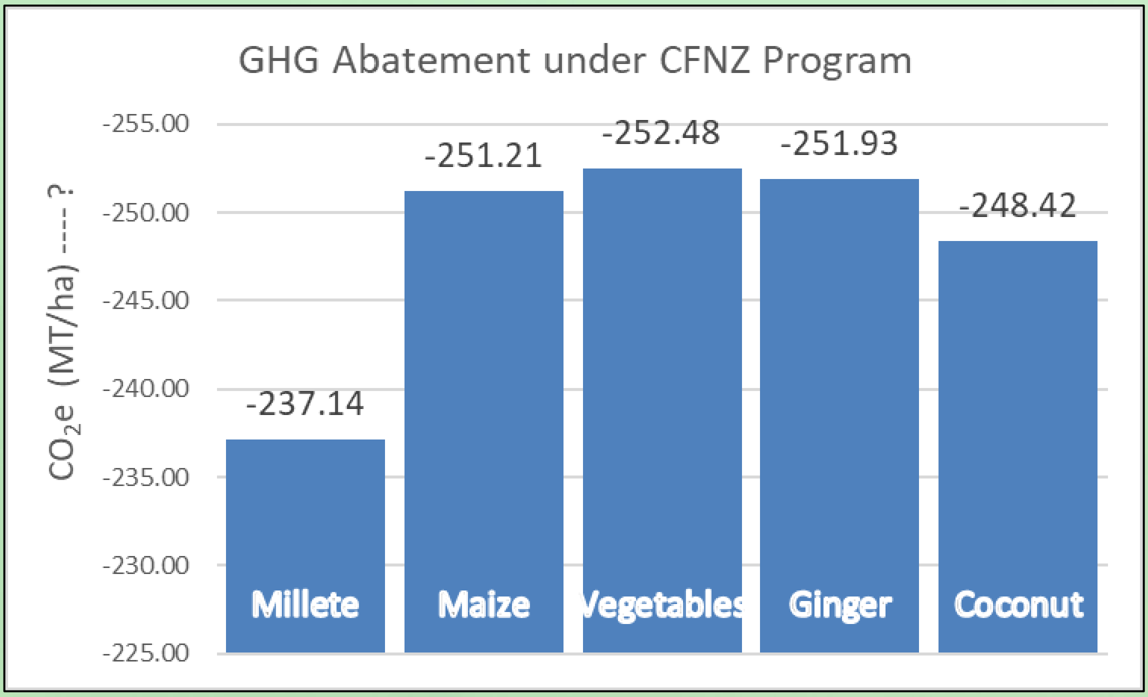

Fig 1 : GHG abatement potential under CFNZ program.

A GHG evaluation conducted using the ACFA (Version 2.0) tool demonstrated that replacing conventional farming practices (CFP) with the CFNZ program yields significant abatement of CO_2e per hectare across multiple crops. For instance, while CFP results for millet, maize, vegetables, ginger, and coconut registered at 1.14, 1.39, 2.65, 2.30, and –1.66 ton CO_2e/ha respectively, the corresponding CFNZ values dropped dramatically to –236.01, –249.83, –249.83, –249.63, and –250.08 ton CO_2e/ha. This translates to GHG abatement potentials of –237.14, –251.21, –252.48, –251.93, and –248.42 ton CO_2e/ha, respectively, thereby underscoring the significant environmental benefits of the CFNZ approach in fostering sustainable and climate-resilient agriculture.

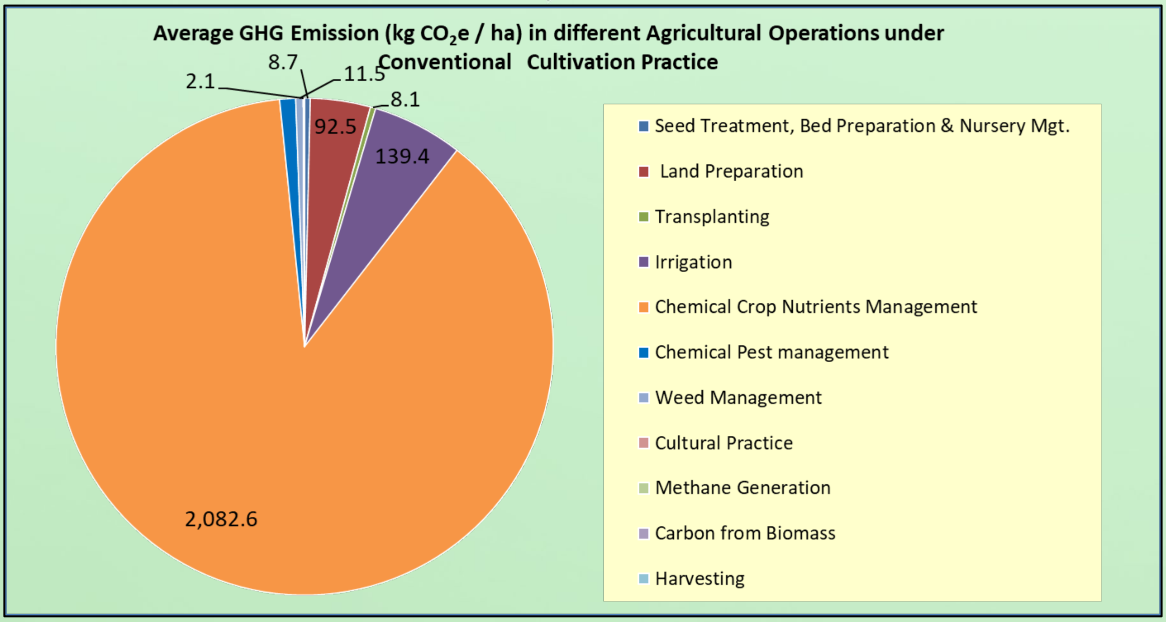

Fig 2 : Average GHG emission ($KgCO_2e$ /ha) of different agricultural operations under CFP at Mandya, India studied under IBM-IORF Sustainability Program

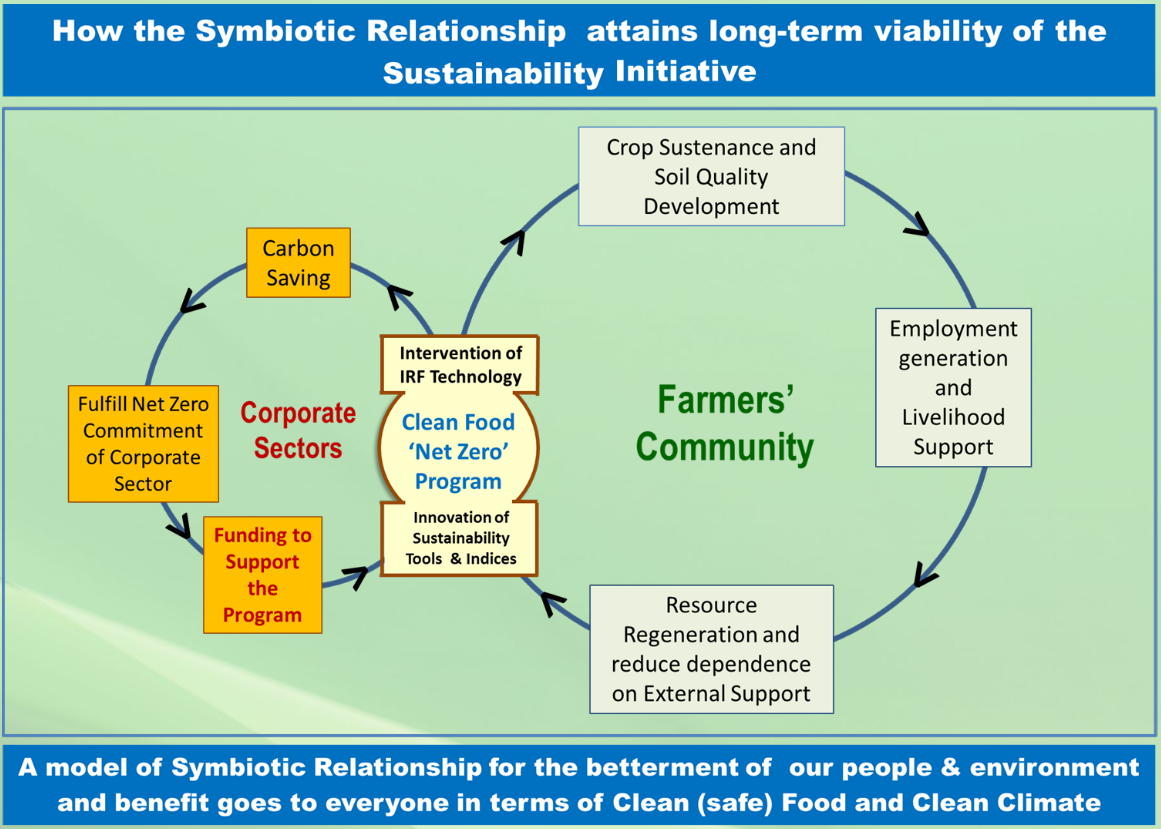

Fig 3 : The Regenerative Agri-Net Zero Model showed a symbiotic relationship between corporate net zero goal and farmers sustainability

Development of the Regenerative Agri-Net Zero Models

The Regenerative Agri-Net Zero Model represents an innovative framework that decouples economic growth from resource depletion and environmental degradation by closing the carbon cycle and promoting waste to compost development movement. This approach integrates waste recycling, resource efficiency, and renewable energy to conserve natural resources while actively mitigating greenhouse gas emissions, and it has been successfully implemented under the IBM-IORF Sustainability Project in Mandya, Karnataka—the first agro-net zero model in India certified by i-NoCarbon, UK. By combining Inhana Rational Farming (IRF) Technology with Novcom

Composting Technology, the project has transformed approximately 2000 tonnes of coir pith, a byproduct of coconut processing, into a high-quality compost applied at 40 tonnes per hectare over a 25.2-hectare area for two consecutive years. The rapid bioconversion process—completing within just 30 days—yields compost that is exceptionally rich in native microflora, which catalyzes soil microbial regeneration and effective carbon sequestration. Beyond enhancing soil health, this model sustains crop productivity, aligns with economic services, and facilitates the production of pesticide-free food, thereby securing sustainable livelihoods.

Moreover, it exhibits a very high carbon mitigation potential; GHG evaluations using the ACFA (Version 2.0) tool reveal that the model can mitigate approximately 250.39 metric tonnes CO_2 equivalent per hectare, in addition to the bioconversion process mitigating around 6000 tonnes CO_2 equivalent per 1000 tonnes of waste and further abating nearly 6300 tonnes CO_2 equivalent by eliminating synthetic nitrate fertilizers. This robust carbon abatement program not only support corporate net-zero and sustainability initiatives but also ensure that the program has no spillover effects or scope for greenwashing. In fact, the model's significant social and environmental footprint establishes it as one of the best decarbonization programs currently available, setting a scalable benchmark for sustainable, climate-resilient agriculture and advancing global sustainable development goals.

Multifaceted Impact Assessment of Regenerative Agri-Net Zero Model : Enhancing Sustainable Agriculture, Environmental Regeneration, and Livelihoods of Small and Marginal Farmers

The Clean Food Net Zero (CFNZ) program represents a transformative advancement in sustainable agriculture by integrating organic soil management, rapid waste bioconversion, and advanced plant health practices to deliver significant environmental, agronomic, and social benefits. Environmentally, the model achieves considerable greenhouse gas mitigation—up to 250 tons CO_2 equivalent/ha—while enhancing soil carbon sequestration by approximately 300 kg/ha/year through the conversion of diverse organic wastes into nutrient-rich compost in just 21 days. This rapid bioconversion process revitalizes degraded lands by boosting soil microflora and earthworm activity and supports pesticide residue–free food production in compliance with FAO-WHO-Codex standards, ultimately reducing chemical input burdens and promoting ecological sustenance across 100 hectares serving over 20,000 consumers. Agronomically, the CFNZ program drives a 15–25% increase in crop productivity relative to conventional practices, simultaneously achieving up to 32% lower energy input and over 60% higher energy productivity, which is further reinforced by the development of climate-resilient organic seeds that enhance farmers' adaptability to climate change. Socially, the model serves as a critical catalyst for the economic upliftment of small and marginal farmers by transferring sustainable crop technologies and comprehensive knowledge support, thereby fostering greater food security and income generation. Furthermore, by bridging the gap between grassroots farming and corporate sustainability efforts, the CFNZ program enables the integration of sustainable agricultural practices into supply chains, aligning corporate initiatives with broader net-zero objectives and Sustainable Development Goals. In summary, this integrated approach not only regenerates environmental health and boosts agricultural productivity but also delivers profound socio-economic benefits, establishing a scalable, win–win framework for sustainable development.

Economic viability of Agricultural Sustainable initiatives: A detailed insight and impact of carbon funding

An analysis of cultivation costs and income indicates that adopting any sustainable project involves extra expenses that erode profitability. Our experience shows that when sustainable practices fail to sustain crop yields or lack technological enhancements to improve system efficiency, the gap in the return on investment (ROI) widens further. Consequently, the cost and return aspects of sustainable projects are seldom discussed within the framework of hard economics, with the discussion taking a holistic view and typically focused on broader environmental benefits—such as enhanced soil health and ecological sustenance—rather than on direct financial outcomes.

Introduction of Inhana Rational Farming (IRF) technology reduces operational costs by sustaining crop productivity and lowering expenses associated with pest and disease management. However, the organic inputs required for sustainable soil management remain significantly more expensive than chemical fertilizers. The adoption of Novcom composting technology further cuts management time, enhances compost quality, and improves the efficacy of soil application. It is evident that conventional sustainable initiatives without technological intervention demand a premium of 80–100% to achieve net benefits comparable to conventional farming practices. In contrast, the introduction of IRF technology effectively narrows the return on investment gap, requiring only a 30–35% premium—particularly when following the Agri-Net Zero model with its intense carbon mitigation objectives. On the other hand, carbon funding under the Agri-Net Zero model can potentially boost net profits by more than 200%.

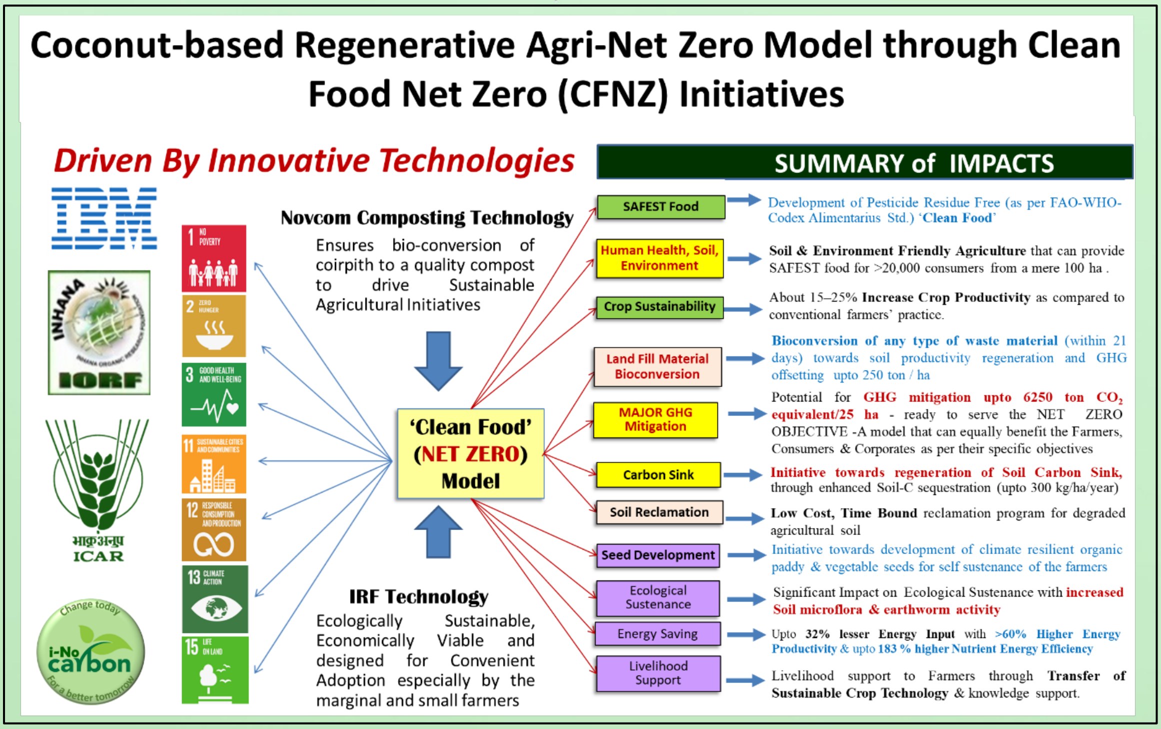

Fig 4 : The Regenerative Agri-Net Zero model driven by Clean Food Net Zero (CFNZ) program through the adoption of Inhana Rational Farming Technology exhibited a multifaceted social and environmental footprint.

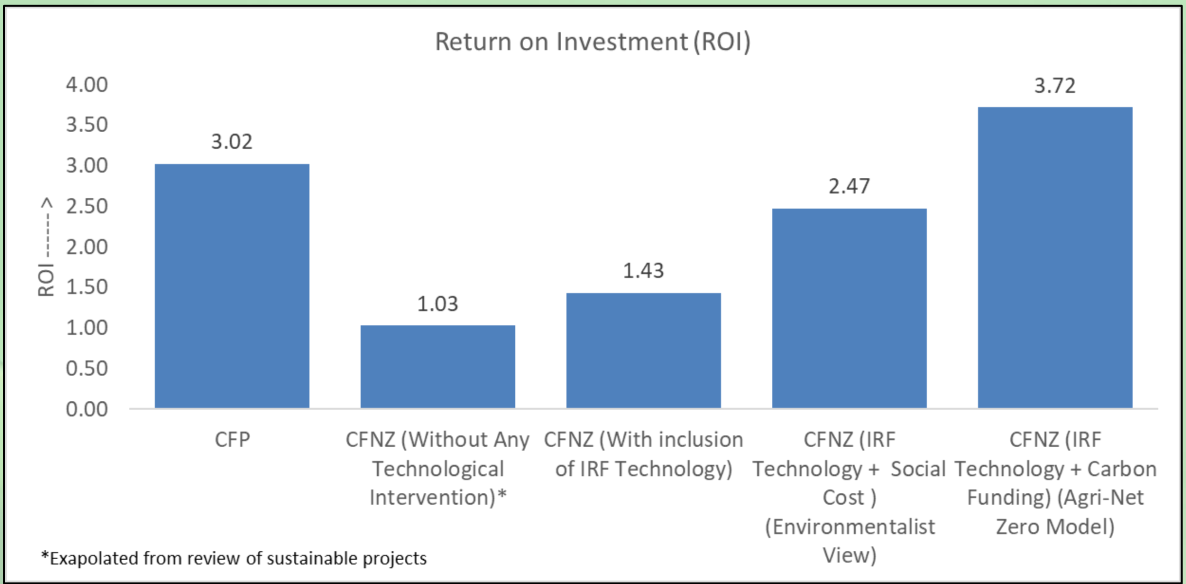

Fig 5 : Return on Investment (ROI) in sustainable initiative – a detailed Insite.

One of the most intriguing outcomes is the return on investment (ROI) in sustainable agriculture. Despite improvements in yield, reductions in pest and disease incidence, and enhanced energy productivity, the ROI for these initiatives remains lower than that of conventional farming—primarily due to the increased costs of sustainable soil management compared to chemical fertilizers. The Agri-Net Zero Model, integrated with climate-resilient regenerative agriculture, offers a promising solution by linking corporate sustainability commitments through CSR, ESG, and dedicated funding with farmers' practices via carbon mitigation objectives. Economic analyses indicate that when generated carbon credits are repurchased at a moderate price (around $60 per metric ton, even when international prices exceed $100), the Agri-Net Zero Model becomes significantly more viable, bolstering overall profitability. While environmental benefits such as improved soil health and long-term climate change mitigation are critical and widely discussed among policymakers, agronomists, and environmentalists, the hard economic metrics of cost and return receive far less attention. For resource-poor farmers, who prioritize immediate operational sustainability over uncertain future gains, expecting them to shoulder these costs is impractical; instead, the lion's share of responsibility must be borne by policy makers, government bodies, and corporate institutions. Sustained support over a three-to-five-year period can further rejuvenate farming systems by gradually reducing soil management costs, enhancing productivity, and enabling fair market price realization, thereby driving the long-term viability of sustainable agricultural practices.

Conclusion

The study decisively establishes the Regenerative Agri–Net Zero Model as a scalable, economically viable, and scientifically robust framework for climate-resilient agriculture. By integrating advanced organic soil and plant health technologies—specifically Inhana Rational Farming and Novcom Composting—within a regenerative, circular bioeconomy, the model delivers transformative outcomes. It substantially enhances crop yields, nutrient use efficiency, and farmer incomes while restoring soil health through increased organic carbon sequestration and revitalization of microbial ecosystems. It achieves significant greenhouse gas mitigation, supports pesticide-residue–free food production, and reduces reliance on synthetic fertilizers—ensuring sustained ecological balance. Critically, the model bridges corporate sustainability goals with the resilience of small and marginal farmers, producing tangible co-benefits such as improved energy productivity, enhanced ecosystem adaptability, and access to carbon financing. Third-party certification affirms its environmental integrity, confirming the absence of greenwashing or negative spillover effects. To accelerate its impact, a clear policy directive is needed to promote nationwide adoption of the Regenerative Agri–Net Zero Model through targeted incentives, carbon credit integration, and its inclusion in corporate ESG frameworks—aligning agricultural sustainability with national climate goals. Altogether, the model sets a transformative benchmark, aligning with global Sustainable Development Goals and offering a future-ready blueprint for corporate ESG ambitions and rural livelihood sustainability.

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