Organic on-field research combined with information technology for fast uptake, sustainable, and profitable future using both macro and micro analysis of the system as a whole

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Abstract. Though organic farming principles are good in food production, quality, and long-term sustainability; its impacts are only at theoretical level. The very slow rate of its uptake and application makes us rethink the current strategies followed at all levels of the organic cycle. Possible reasons include less representable, intercommunicable and usable data with fewer studies focussed on long term variation parameters on open fields and their effects on the system as a whole. The findings of current research studies based on the micro views of scientific principles with few factors in space-time controlled, semi-controlled and small open field environments, are not quickly adaptable at open field level. As open fields are vastly managed by natural system's unpredictable and ever-changingbehavior, they are difficult to understand and apply by the practitioners who are tied to the socio-economic factors. Our new research methodology focuses in making both ends meet by using real-time application of latest technologies such as electronic and information technology in the field, easing the handling of data and operations of the organic practitioner at both micro and macro levels. This method, when combined with a macro view and analyses of natural system principles as a whole, helps reduce not only the failures and their causes but also increases the productivity, quality, and sustainability at all spheres of the organic system. The results of the research conducted are recorded keeping the system as a whole entity taken from open field experiments on it. This involves experiments using different combinations of physical (land and water) and biological (ecosystem) factors. Then using those results on humans, their health and socio-economic impacts are studied to improve the organic system process at all levels.

1. Introduction

Food production, sustainability, and its security are currently more challenged by the excess degradation and depletion of natural resources by modern society throughout the world than in the past [1]. Even though the past results showed that the increase in food production in shrinking land resources was possible by using emerging technologies; its aftereffects depleted the available resources and created health complexities all along its journey. Organic farming and sustainability seem to be emerging but its conversion rate is far slower than expected. Possible information and data factors include:(1) No clear proven strategies to promote organic system benefits and uptake to end users in the understandable and applicable (health, cost, and long-term benefits) terms;(2) The data accessible by organic practitioners/managements who are the real-time research people are often highly represented standards, while the changes in open field scenario are always under-represented and don't help in their open field operations;(3) The focus and representation of scientific views and principles are mostly micro-oriented, very short term, conducted in a controlled environment and as

disconnected functions of micro units from the system as a whole;(4) Very less focus on systematic studies in on-field research, long time varying parameters, uncontrolled environments and socio-economic parameters and its applications; and(5) Less promotion of information technology services and real-time data management practices in open-field with the organic practitioner as central researcher and contributor.

Our new research methodology focuses on:(1) Recording the long time series data of experiments conducted on the vast open field and helped in unearthing the essential data hidden in nature;(2) Application of information technology, data visualization and analytics using field centric variation parameters helped to manage better and reduce the problems (drought and labour), and its causes (no mulching), reduce rework (tilling and weeding), improve sustainability (less water and energy), production, quality (increasing the health) and profitability;(3) This method, when combined with the sustained use of natural resources, with widespread availability of knowledge base and support, novel innovations and adoptions techniques to increase the open field usage by farmers and brings great benefits to all the stakeholders involved and takes the organic sector to the next level; and(4) To prove by applying this new way of research method in approaching the system as a whole brings in major human health changes that could lead to potential discoveries of healthcare products and medical drugs.

2. Materials and Methods

On-field research and trials were conducted at the private farm in Anaimalai, CoimbatoreDistrict, India (10°58'N, 79°93'E, 258 m a.s.l, 27°C, 1359 mm, Red loam soil) in the seasons of 2009/10, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16. The research is being conducted on different food crops-seasonal and perennial crops as follow:(1) Cassava (Kumkum Rose)–2009/10 and (M4)–2010/11;(2) Coconut (Indigenous Tall–100 Trees)–2011 onwards;(3) Millets (Indigenous), Paddy (Indigenous-KattuYanam) and Oil Seeds (Groundnut and Blacks sesame)–2014/15; and (4) Vegetables (Brinjal (Indigenous), Ladies Finger, Cabbage and Cauliflower)–2014/2015. Organic andnatural farming technologies and best practices such as mulching, manuring (Farm Yard Manure (FYM), Jeevamirtham, and Panchagavya), and water conservation practices (maximum utilization of rain water), intercropping (gliricidia, banana, and legumes) applied to the above crops in the respective years. Different types of mulching such as Coconut Leaf, Coconut Husk, Coconut Fibre, Coconut Peat, and live, leaf and plastic mulching were applied to the respective crops in continuous stages over time. Application of water conservation methodologies such as changing the landscape and land preparation methods in synchronous to mulching methods to arrest maximum rainwater were implemented using machines & manually. From the starting of changes in the on-field system process, its changes over time, results and its effectiveness in improving the sustainability of the farm and their impacts on human health and standards are recorded using handwritings, book keepings and electronic and digital media devices.

2.1. Application of electronic and information technology in plant phenology

Capturing visual image data in the visible spectrum of electromagnetic radiation motivated the on-field research at combining both the macro and micro level parameters of sustainability [3]. For this use of consumer grade digital imaging cameras like KODAK Easy share M522, NIKON Coolpix L26, SONY Cybershot DSC-W830 outperformed over our initial usage of sophisticated devices in both visible and IR domain that requires sophisticated changes, the high cost and unease in availability in the market withouthampering our research. They are lighter and perform better equaling bulk ones involatile open field operations.Imaging the field at pre-fixed chosen spots in the farm to monitor hourly, daily and seasonal changes in the system are done initially. Next,imaging all the designed functions as in table 1 was carried out in the field in all dimensions and views. Weather, climatic variations, and seasonal changes data and their responses in biosphere were also visually recorded along with agricultural measurements taken from the local departments.The production results (harvested foods) of on-field research were tested for humanconsumption and its impacts on health

were recorded over time. Before this, a thorough datacollection and analysis of various health and medical philosophies ranging from yoga to modern medical sciences were done [3]. Most of the health parameters of the humans were tested and recorded prior to the usage. The visual data of the intakes and excreta, recording the opinions about the quality, taste and their current health status about the body and mind were also taken into account. Figure 1 shows the proposed macro level model of the organic system for improving the sustainability in all spheres.

Table 1. On-field experiments on cultivation of different food crops and their strategies.

Crop	Year	Land Preparation	Manuring	Irrigation	Water / Energy Conservation	Mulching	Pest & Disease Control	Weeding
Cassava (Kumkum Rose)	2009 / 2010	Machine & Manual	FYM	Surface Irrigation	No	No	No	Machine & Manual
Cassava (M4)	2010 / 2011	Machine & Manual	FYM, Jeevamirtham&Panchagavya	Rain Fed	Yes	Coconut Fibre & Live Mulching – Cowpea, Green Gram	Organic Pest Control Methods	Manual
Coconut (Aged 25 Years & above)	2011 / 2012	Machine & Manual (Initial)	FYM, Natural Farming Principles	Initial (during transition), Rainfed	Yes – Changed Irrigation to outer ring	Coconut Leaf, Husk, Fibre, Peat & Live Mulching	No	No
Paddy, All Millets & Oil Seeds	2014	Machine & Manual	FYM	Rain Fed, Sprinkler	Yes	Natural Farming Principles	No	No
Vegetable	2014 / 2015	Machine & Manual	FYM, Jeevamirtham&Panchagavya	Drip, Sprinkler Irrigation	Yes	Plastic – Biodegradable & Reflective Silver Mulch	Organic Pest Control Methods & Traps	Very less manual

To solve the huge memory space requirements of storing Terabytes of image data we used MATLAB Technical computing software to automatically acquire the images, to compress the data and stored them in the database. The vast amount of visual data of on-field changes were manually classified based on the time, on-field operational research strategies, sustainability at both macro and micro level with scientific principles of agriculture. Digital Image Processing [4], Computer vision, and MATLAB technologies are used for illumination and noise corrections, image enhancement, scene change detection, object detection, and classification from the time series data of manually classified images. The output data of the above experimental process (could not be presented here because of space constraints) combined with the standard measurements are being studied to help in disseminating the complex information hidden and interwoven and shows promising results practically in all the spheres of the organic system as a whole.

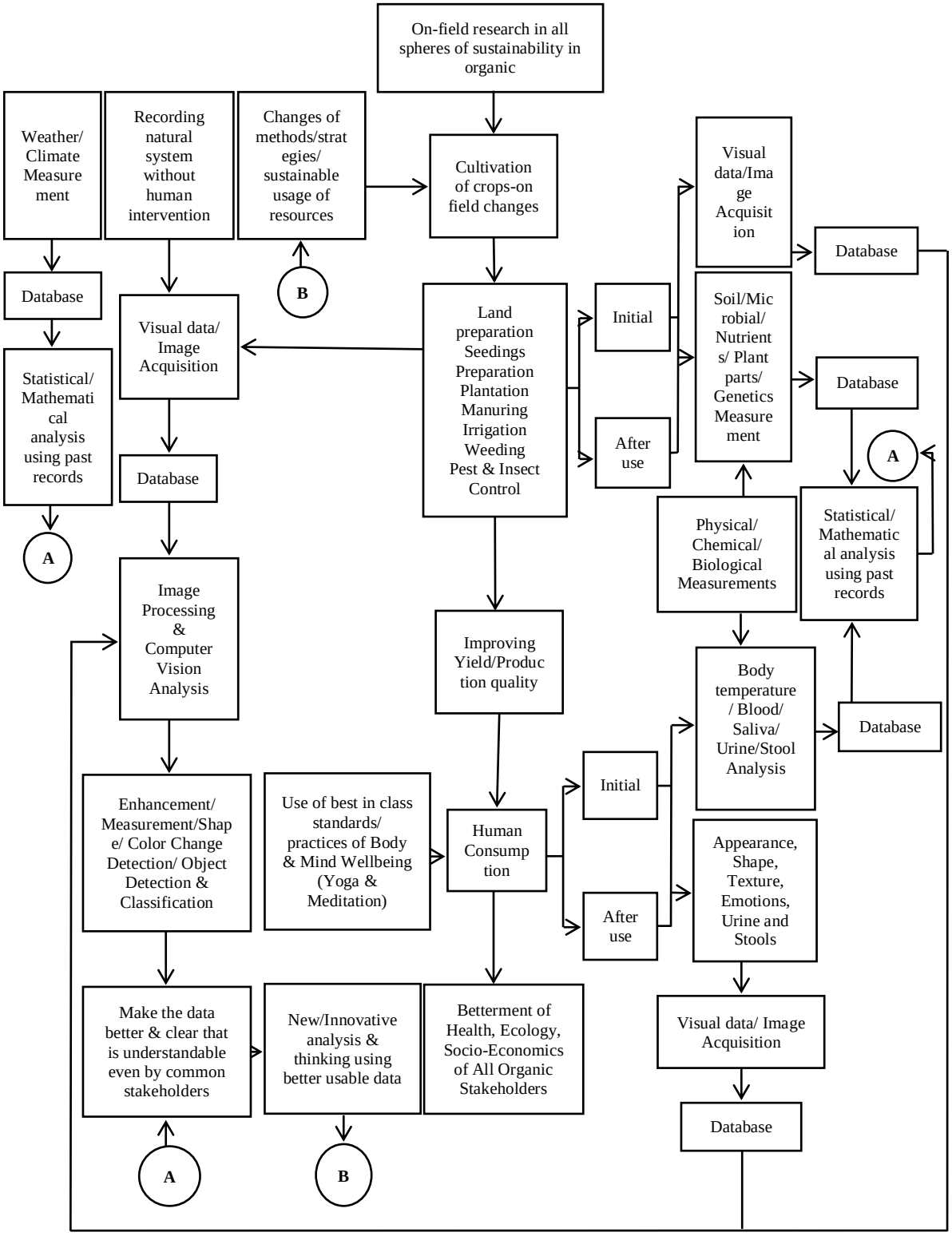
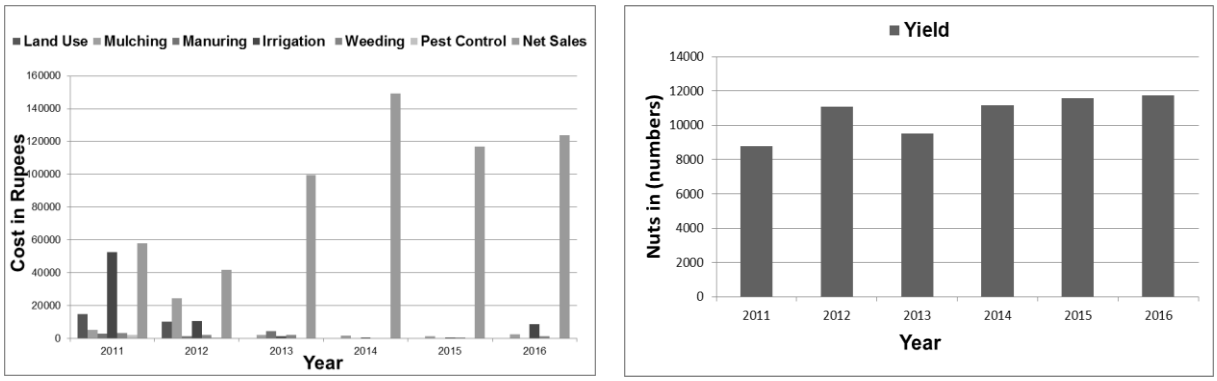


Figure 1. The proposed macro level model for improving the sustainability of the organic system.

3. Experimental Results

The results of on-field trials on 100 coconut trees (over 25 years) conducted in the above-mentioned private form over a long time clearly show that the coconut treesadapt to the climatic and seasonal weather changes when proper land utilization and water conservation strategies are implemented. In 2011/12 the changes in land preparation were done including pits that were dug exactly in the circumference of the tree with the longest leaf in horizontal length. This process not only arrested maximum rain water but also keeps them for a long time with radial mulching techniques using coconut fibers and husks. Figure 2 clearly shows that during the initial 2011 and 2012 periods, more disturbances in land occurred during preparation, the irrigation with mulching costs increased and the yield in the next consecutive year in 2013 decreased.

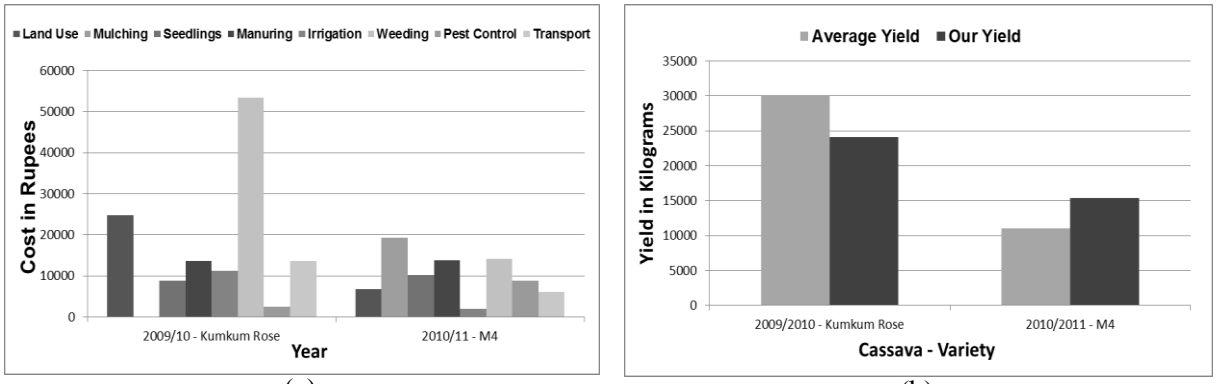
At the start of 2012, *Gliricidiasepium* was interplanted for Nitrogen fixing and from middle of 2012, the irrigation for the coconut trees was stopped completely and made to thrive on its own with the natural system. Then the yield got more stabilized from 2014, 2015 and 2016, and doesn't get affected due to the weather and drought changes because of moisture keeping tendency of radial mulching techniques using fiber and husk.



(a) (b)

Figure 2. The cost wise impact of on-field parameters (a) in Coconut and their interconnections with the performance in long term (b).

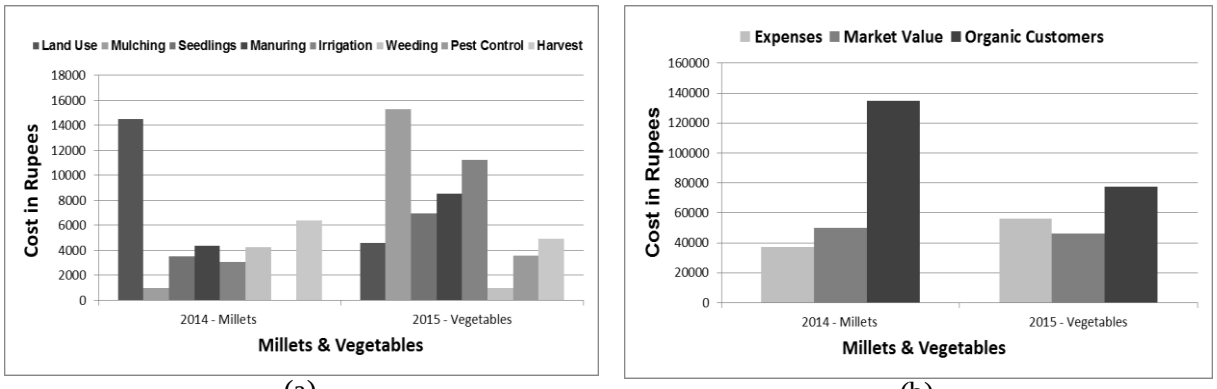
The research experiments in Cassava as a mono crop was done using one-hectare land of the above-mentioned farm using a general variety-Kumkum Rose (2009/10) and food staple variety-M4 (2010/11) widely used in India. Figure 3 shows that intense utilization of land, water, and human resources for Kumkum Rose variety achieved only 24T/ha when compared to the average yield of 30 T/ha. This is due to the scientific fact that at micro levels, the high competitions from weeds for nutrients due to surface irrigation increased. Whereas 15T/ha of M4 variety results exceeded the recorded average of 11T/ha. Though M4 variety was tested mostly as rain-fed, the mulching of coconut fiber worked very well in reducing the soil temperature and keeping the moisture for long period of dryness. This is verified from figure 3, the cost of operations on the field level is directly related to the physical and biological level of the system as a whole. The time series records of visual data combined with other on-field micro level measurement data of the operations and the cost measurements are helpful in further fine-tuning of future operations in achieving better sustainability.



(a) (b)

Figure 3. The cost wise impact of on-field parameters (a) in Cassava and their interconnections with the performance in medium term (b).

The on-field research was conducted on all millets types (indigenous varieties) in the 1-hectare land, paddy (indigenous variety-Kattuyanamand*Mappilai samba*) and oil seeds in mixed plots of another one hectare of land. Millets were maximum rain-fed and irrigated by sprinkler to sustain production. Vegetables (Brinjal, Ladies finger, Cauliflower, and Cabbage) in 2014/15 were also done in 0.5 acres of post millet cultivated the land. Plastic mulching was tested with drip irrigation to reduce the weeds, water efficiency, and to reduce labor rework from the results of past experiments. Being primary food consumables, careful observation and visual image data records were efficiently used on-field in process improvement. Figure 4 shows interesting facts about not only on sustainability at field level but also on profitability. Primarily due to closed space in Millets growth, weeding problem didn't affect the system performance. The same can be observed in Vegetables also, as we used plastic mulching technologies to get more benefits. For manuring, Panchagavya and Jeevamirtham were made in the field and used along with Farm Yard Manure. No pest damage was identified in Millet's group more damages were done by birds and this was not at all expected. Integrated pest management practices such as organic pest solutions, insect traps and natural trap flower plants like marigold were followed in vegetables. Bitter results were seen from figure 4 in selling and consuming facts. The general marketplace and price didn't guarantee for profitability, so direct selling and marketing to organic customers increased the profitability.



(a) (b)

Figure 4. The cost wise impact of on-field parameters in Millets and Vegetables (a) and their interconnections with the performance in the market (b).

The main findings of this research method show that by applying macro level analysis of the system as a whole using time series visual data of on field changes with image processing results were combined with the standard measurements of weather parameters (rainfall and temperature) clearly showed our system as a whole performed better at macro level than the micro view of modern agricultural technologies. This includes:(1) Achieving higher sustainability of natural resources such as water and agricultural land due to problems caused by global warming and deforestation;(2) Increasing the performance in vegetation health;and (3) Increasing the production quantity and quality over vast climatic variations, drought, weed problems, pests and diseases amidst lack of human resources, which is going to be the future of agriculture. Then the quality of the products was analyzed to detect changes in properties using all forms of data, it clearly demonstrated that complex changes in immunity (capacity to retain the sustainability from micro level) increased at all levels of the system as a whole from the changes in agricultural field to changes in human body as shown in figure 5.

The results were surprising initially and first of its kind in using the above stated methods to bring the health impacts in humans and it has been verified multiple times with different age groups, geographical location and in multiple scenarios. Further trial and error experiments are being conducted to find exactly what kind of changes and processes in on-field and natural systems that play in major health impacts in humans and to lead potential discoveries of healthcare products and medical drugs.

(a) (b)

Figure 5. The final proof of the macro level view and working of the system as a whole; interconnections of on-field parameters with the human body; reversing of aging-the white hair is returned to black (a) and psoriasis in legs getting almost cured (b).

4. Discussion

Application of near and far field plant phenology in organic on-field research helped unearth the data about complex interconnections and the effects of huge multiple physical entities such as climatic variations, environmental changes, and its relation to vegetative health both intra-annual and annual and finally its impact on human health which is the most important. The time series visual data that was collected from the starting of the on-field research combined with standard measurements were stored in a database and used for further data extraction, visualization, and analysis using scientific research tools. This data could be further used by researchers, technologist to study and develop new methods that could be easily understandable and applicable by farmers and all organic stakeholders at both macro and micro level.

This new method of approaching the system can be mainly used to develop potential medical and health related drugs and products from the plant products as it is evident from the above outputs. This new method of storing, processing and using the 1 and 2-dimensional data to understand the finest changes both at macro and micro level promises to bring results and adds new dimension in up-taking the organic sector faster and improve the sustainability in all spheres of on-field, ecosystem, health, and socio-economic of the system as a whole and combined.

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