Maximising vegetable yield for small landholding farmers in Alibaug, Raigad (North Konkan Coast), Mumbai, Maharashtra

Project Name: Upaj Badao (Maximise Crop Yield)

Category: Plant Sciences
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Synopsis
Over 100 million Indian farmers rely on agriculture as their primary source of income, with 65% of the farmers operating on small land holdings (less than an acre). These farmers employ outdated, laborious, and time-consuming practices which don't grant them maximized yield. Left unable to maximize their own crop output, millions of farmers are left helpless and face severe economic implications. This research project is based on extensive primary research to improve soil macronutrients (N, P, and K) and micronutrients (Zn, Fe, Cu and Mn) which are essential for healthy plant growth and how the findings can be utilized for the economic upliftment of the farmers.

The primary research objective is twofold - to increase the yield productivity of farmers through recommending most optimal agricultural products, methods to ameliorate soil health, and crops gathered by primary field trials and to provide farmers an easily accessible app which collates all collected data and recommends best methods to grow crops and improve soil health per season.

A test site was identified in Alibaug in Raigad district of Maharashtra state, outside Mumbai. Being overgrown with weeds and full of rocks and obstacles, the site needed to be completely cleared through cutting and cleaning. Next, in order to prevent local animals from entering, a fence was built around the test site (bamboo sticks connected by net). The soil test results showed a slightly acidic soil with a low pH of 5.87. The NPK ratio was found to be below the optimal level of 4:2:1 with phosphorus and potassium insufficiency. A deficiency in micronutrients namely magnesium and sodium were also observed. The control site soil was treated with organic manure and natural soil conditioner to increase the soil pH, enhance the water holding capacity and particle size of soil and supply essential nutrients to the plants in an organic way.

The data leveraged for recommendations to the farmers is first-hand primary research data with live field trials on a specific piece of land in Konkan region with unique soil conditions. The problem statement generated is from the first-hand account of the farmers in the region who have been experiencing low yields over the years and their lack of education and accessibility to resources limits their understanding of the underlying causes and to employ the latest techniques to improve yield and hence their income. The extensive research has generated deep insights about the soil health in the region and how treating the soil with the right products can yield higher growth. For the region, such an accessible and easy to use collation of data that the farmers can use is previously unseen and is 100% customized for the

specific region. The app is easily extendable to other regions in order to create a wider spread impact. The farmer is prompted to choose a season on the App which then navigates the user to the recommended crops for that particular season. The recommended crops and their steps have been visually portrayed in the form of a flowchart.

An increase in yield for the selected vegetables (incl. tomato, cucumber, bottle gourd and chilli) demonstrated that fertilizers used for soil treatment and methods used to grow the crops increased the yield by 20-30%.

1. Introduction

My project is focused on soil management for maximising vegetable yield for small landholding farmers in North Konkan coast in Maharashtra. The coastal region in Raigad district is largely an agricultural belt dominated by small farmers whose livelihood depends on farming. This research project is based on extensive primary research around macronutrients (N, P, and K) and micronutrients (Zn, Fe, Cu and Mn) which are essential for healthy plant growth and how the findings can be utilised for the economic upliftment of the farmers.

2. Background

- 22% of Indians rely upon agriculture as their primary source of income.
    - 82% of these farmers have small land holdings, leaving them with insufficient means to improve their own yield.
- A majority of the farming population relies on conventional farming instead of organic farming, resulting in neglection of soil health.
- In rural settings, almost all farmers exercise outdated and comparatively unproductive practices.
    - Use of organic seeds.
    - Use of inefficient fertilisers.
    - Inefficient choice of types of crops to plant per season.

3. Personal Connection to the Project

My grandparents live in a small village in district Bilaspur in Himachal Pradesh, where I often visit them. The primary source of income in the area is through farming which includes crops (wheat and corn), vegetables (as per season) and pulses. As my visits to the area happened during my school holidays (Diwali, Holi and Summer breaks), I was able to see farmers growing different crops/vegetables/pulses during each visit. Around my grade 10 I began to closely observe the farming methods adopted, agricultural tools used, and sowing practices followed by the farmers. It was clear that these farmers were putting in a substantial effort to grow crops, however I observed that the productivity of their efforts, which was ultimately reflected through the crop yield, was way less than what it could have been. This sparked my interest in the farming life cycle as I felt strongly that these farmers lacked a know-how of proper techniques to maintain a healthy soil and lacked knowledge of and access to quality agricultural tools and products.

This led me to think about how such small landholding farmers, who do not have any other means of generating a livelihood, can maximise their crop yield. These small landholding

farmers were all the more at greater risk with adverse climatic changes i.e., if rains are too heavy or get delayed or arrive at odd times. As soil is one of the most critical components of the chain, I decided to carry my own first-hand research on improving soil health for growing most suitable vegetables. Since I reside in Mumbai, I selected a local site for my research in district Raigad at Tehsil Alibaug at a village called Kolgaon. It is a coastal village spread over 250 hectares and its entire population of around 900 relies on agriculture as their main source of income.

4. Objectives of the Study

I. Increase the yield productivity of farmers through recommending most optimal agricultural products, methods to ameliorate soil health, and crops gathered by primary field trials.

II. Create an easily accessible app for the farmers, which collates all collected data and recommends best methods to grow crops and improve soil health per season.

5. Research Method

Location: Kolgaon, Tehsil: Alibaug, District: Raigad, Maharashtra
Time frame: September 2021 to current date

Primary Research Sources	***Secondary Research Sources***
● Conducted the research at Kolgaon Village in Alibaug, Raigad region ● Interacted with local farmers, carried interviews ● Interacted with local agricultural shops. ● Visited the Government's Soil Testing Lab at the District Agricultural Department in Alibaug for interactions with officials ● Discussed Soil Test Report with officials at Italab Private Limited in Mumbai	● Research was conducted online. ● Consulted a variety of sources ranging from blogs to articles to videos. ●

6. Collection of Soil Samples:

a. Soil samples were collected as composite samples as spot samples are not reliable due to potential risk of contamination with inorganic or organic fertilisers. The collected samples are called Represented Soil Samples.
b. Represented Soil Samples were collected with wooden tools to avoid any contamination of the soil.
c. Four pits were dug for each sample. From each pit, a sample was collected at a depth 20-30cm. A composite sample of about 1kg was taken through mixing of represented soil samples.

d. All composite samples were dried in the open sunlight and then ground and wooden/leafy particles were filtered out.
e. All the samples were packed in the polythene bags for laboratory investigations.

7. Soil Test Results

Three soil samples were taken for testing as summarised below.

Testing Date	**Soil Sample Location**	**Testing Lab**	**Testing Parameters**
10 October 2021	Kolgaon	Italab, Mumbai	Ph and NPK and Micronutrients
12 October 2022	Kolgaon	Italab, Mumbai	Ph and NPK

Test Results

TABLE 1
Test Date and Site Location: 10 October 2021, Kolgaon, Alibaug, Raigad, Maharashtra

Parameter	**Unit**	**Ideal Range**	**Test Reading**	**Comments**
pH		6.5-7.5	5.87	Medium
EC	dS/m	0-1	0.08	Simple
Organic Carbon (OC)		0.40-0.60	2.16	Excess
Nitrogen	Kg/Ha	280-420	568.24	Sufficient
Phosphorous	Kg/Ha	14-21	2.97	Very low
Potassium	Kg/Ha	150-200	139.94	Low
CaCO3		2.5-5.0	2.5	Medium
Calcium (Ca)	%	4-9.99	23.08	Excess
Magnesium (Mg)	%	0.50-3.99	0.49	Low
Sodium (Na)	%	5-15	0.73	Low

TABLE 2 - Latest soil test readings
Test Date and Site Location: 12 October 2022, Kolgaon, Alibaug, Raigad, Maharashtra

Parameter	**Unit**	**Test Reading**
pH (10% solution)		7.19
Nitrogen	%	0.13
Phosphorous	%	0.06
Potassium	%	0.10
Calcium Carbonate	%	1.25
Calcium Assay	%	0.50
Magnesium (IEP-OES)	%	0.61
Sodium (IEP-OES)	%	0.15

8. Analysis of Soil Testing Results:

a. The results show that the soil is slightly acidic in nature with pH on the lower end (vegetables such as Tomato and Cucumber require an acidic soil).
b. The soil has an imbalance of NPK macronutrients. The Phosphorus is very low, and Potassium is low.
c. Magnesium and Sodium micronutrients are low.
d. The soil test data shows the soil is deficient in NPK and micronutrients which means the soil health is poor and requires treatment with fertilisers and manures to make the soil suitable for vegetable plantation.

9. Soil Treatment and Seed Planting:

a. Project site was divided into two parts - a control site and a non-control site.
b. Each site area was around 900 sq ft in size.
c. Control site Soil was treated with organic fertilisers - organic manure and natural soil
d. conditioner. The objective was to enhance the soil health through removing deficiencies in NPK and micronutrients as observed in the soil test results.
e. Seeds were planted in October-November 2021.

10. Vegetable Yields Observed

Over the six-month period, between October 2021 and April 2022, the project site was used for growing three key vegetables. The outputs observed through the yield in vegetable production is summarised below.

CUCUMBER

	Control Site	**Non-Control Site**
Area (sq. ft.)	400	400
Field Set Up	4 rows, 5 mounds in each row	4 columns with 5 mounds each = 20 mounds
Organic Fertiliser Applied	Manure - 450gm/sq. ft. Soil Conditioner - 1.5gm/sq. ft.	No fertiliser applied
Soil Mounds Created	Four columns with 5 mounds each = 20 mounds	Four columns with 5 mounds each = 20 mounds
Total Seeds planted across mounds	80	80
Actual No. of plants per mound	45	40

no. of Fruits (Vegetable) per Plant	6 cucumbers 	5-6 cucumbers 
Vegetable Colour, Size and Weight	Dark green, 15-18 cm, 300gm	Dark green, 12-15 cm, 275gm
Total Yield	No. of plants * yield per plants * weight 81kg	No. of plants * yield per plants * weight 66kg
Yield Difference	23% (Control Site over Non-Control Site)	

BOTTLE GOURD

	Control Site	**Non-Control Site**
Area (sq. ft.)	350	350
Row Spacing	4 rows with a spacing of 200cm Plant spacing of 30cm	4 rows with a spacing of 200cm Plant spacing of 30cm
Organic Fertiliser Applied	Manure - 450gm/sq. ft. Soil Conditioner - 1.5gm/sq. ft.	No fertiliser applied
Total Seeds planted across mounds	24	24
Actual No. of plants per mound	16	16
Fruits (Vegetable) per Plant	4-5	3-4
Vegetable Colour, Size and Weight	Light Green and yellow, 750gm 	Green, 600gm 

Gross Vegetable Yield	No. of plants * yield per plants * weight 52kg	No. of plants * yield per plants * weight 40kg
Yield Difference	30% (Control Site over Non-Control Site)	

TOMATO

	Control Site	**Non-Control Site**
Area (sq. ft.)	150	150
Field Set Up	Four rows with a spacing of 30cm	Four rows with a spacing of 30cm
Organic Fertiliser Applied	Manure - 450gm/sq. ft. Soil Conditioner - 1.5gm/sq. ft.	No fertiliser applied
Average Seeds Planted per Row	25	25
Actual No. of Plants per Row	13-14	9-10
Size of plant and no. of Fruits (Vegetable) per Plant	Height 50-60cm, 10-12 tomatoes per plant 	40-50cm, 6-7 tomatoes per plant
Vegetable Colour, Size and Weight	Dark green,	Dark green
Total Yield per Mound	Sudden weather changes at the end of November and early December of 2021 (rains and less than normal temperature) severely affected the growth of plants which turned yellow and eventually dried leading to no output.	
Gross Vegetable Yield	Not Applicable	
Yield Difference	Not Applicable	

11. Recommendations

Based on the project site data, the following are the recommendations for optimal vegetable production for the farmers (*these recommendations have been incorporated into an Android Software Application which is accessible to the farmers as described in the next section*).

Soil Fertility:
Soil fertility was identified as the key driver for the coastal farmers at Alibaug when evaluating an optimal vegetable yield. The local soil contains an adequate amount of Nitrogen (N) with low Potassium (K) levels and severe deficiency of Phosphorus (P). The pH level shows slightly acidic properties, but this may not be sufficient for growing vegetables like tomatoes which require a good degree of acidity in the soil. Another key observation was lack of micronutrients (Mg and Na) which is likely to restrict the growth and quality of the vegetables.

Site Preparation:
- The sowing site should be exposed fully to the sun, vegetables like tomato and cucumber require a lot of sunlight.
- Soil must be moist and fertile (not soggy).
- The soil must have a pH level between 6.5-7
- Nitrogen-Phosphate-Potassium (NPK) levels of the soil should be in the ratio of 5:4:8
- Compost and fertiliser are recommended to prepare the soil for adequate nutrition requirements.

Nutrition Management:
The soil was treated with organic fertilisers including compost and green manure (developed from composted cow dung). The manure is a very good fertiliser rich in organic matter that helps to improve aeration and the breaking up of compact soils. It is rich with beneficial bacteria that convert soil nutrients into readily available forms for the tender plant.

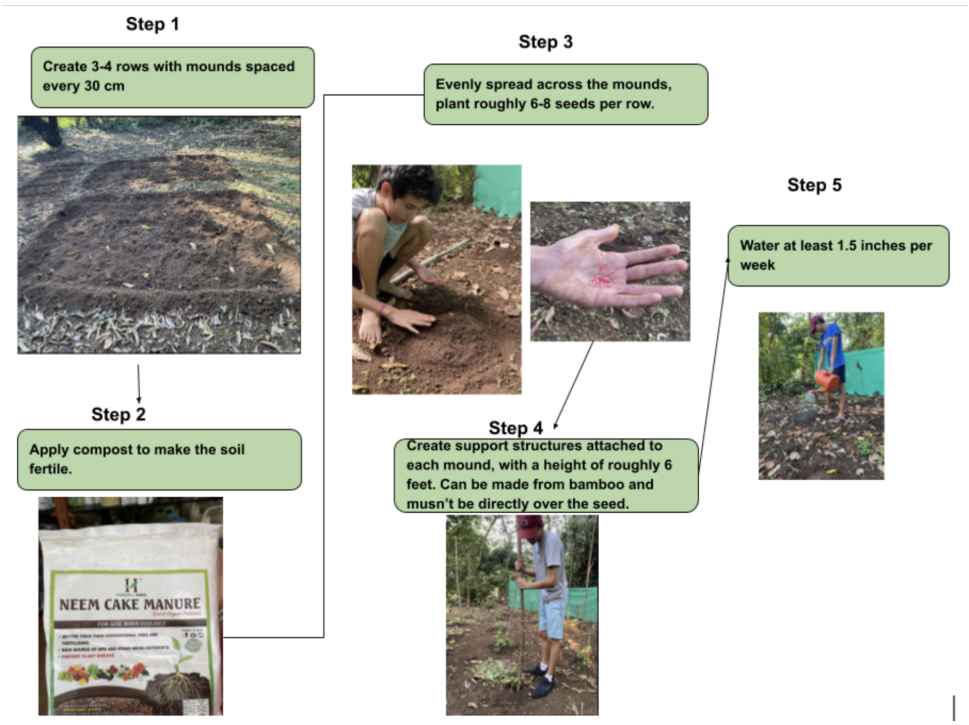
Bhoo-grow was used as a soil conditioner to improve the soil pH and the water holding capacity and particle size of soil. Bhoo-grow supplies essential nutrients to the plant in an organic way because it contains natural elements like Bone meal, Seaweed extract, Amino acid, Humic acid, Dolomite, Bentonite, Vermy-Wash and Goumutra.

- Go garden Urea Fertilizer (46% Nitrogen)
- Aavya Agro Organic Manure
- Bhoo Grow Natural Soil Conditioner - For soil micronutrients.
- Vermicompost

Fertiliser Application

Organic Fertiliser	Fertiliser Amount Added (Control-Site, 900 sq. ft.)	Key Benefits
Manure (Cow Dung used)	40Kg, @450gm/sq. ft.	To supply enough nutrients, additional nitrogen fertiliser may be required.
Soil Conditioner (Bhoo Gro used)	1.5Kg, @1.5gm/sq. ft.	To improve pH and water holding capacity and particle size of soil.

12. Vegetable Flowcharts Used in App

Bottle Gourd	

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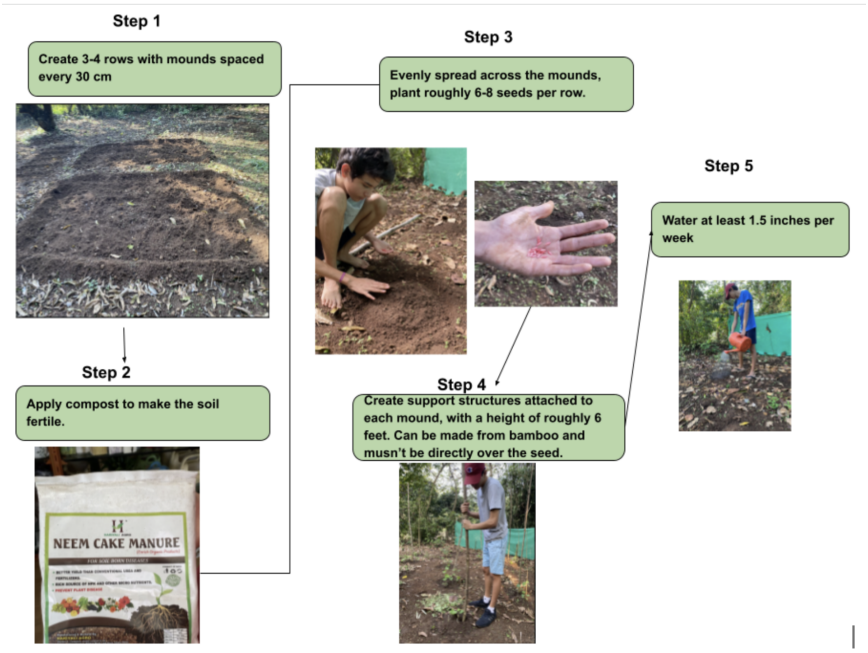
<td> 
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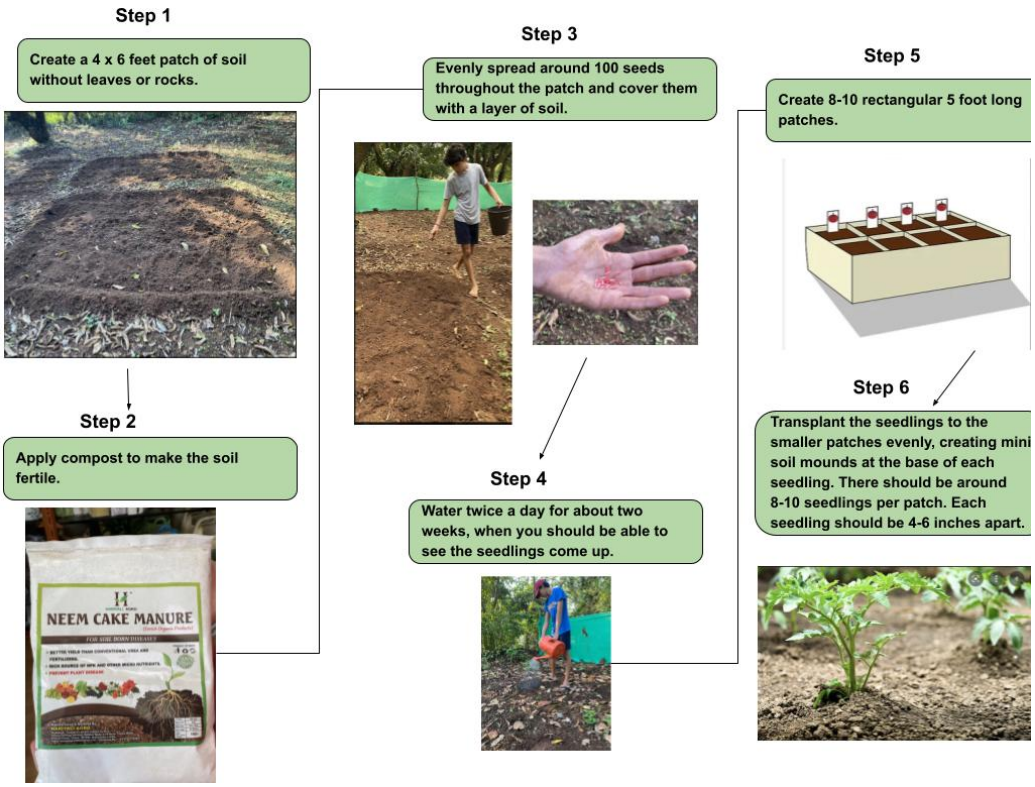
<td> 
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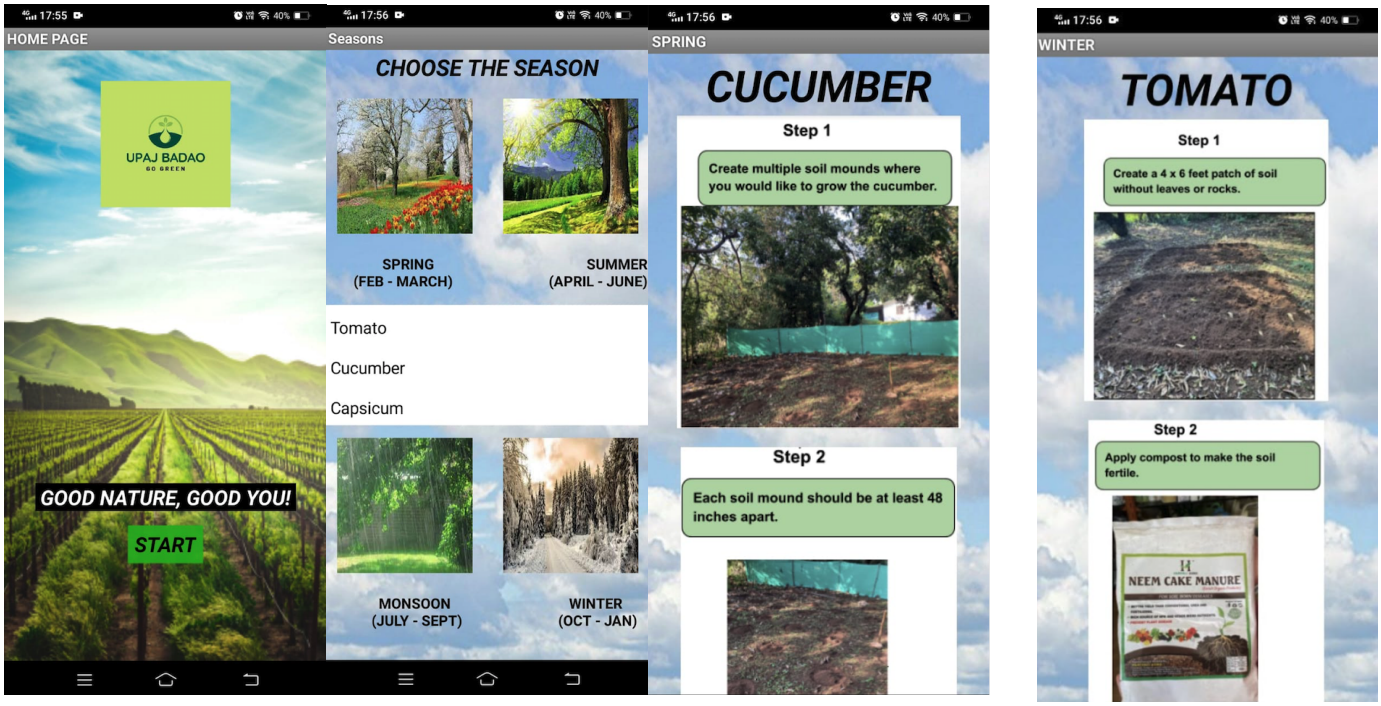
13. Android based Software App for the farmers

Based on the primary and secondary research data, an Android based App called ***"Upaj***

Badao" *(maximise crop yield)* has been developed using JavaScript. This App offers simple functionality and pictorial guidance making it quick and easy for farmers to navigate and understand

A farmer can first choose the season based on which the App provides recommendations for most suitable vegetables. Once a specific vegetable is selected, the farmer is provided step by step guidance on soil preparation and nurturing and seed plantation techniques. The App provides recommendations on specific organic fertilisers to enhance soil health.

My next step is to make the App Vernacular so that it is scalable and flexible to incorporate local languages.



14. Working Pipeline

I aim to further extend the project during the year through the following three steps:

- Enhancing soil health to deal with any ***adverse impact of climate change*** (as was seen during my Project Site with an adverse impact seen on tomato plants). The coastal soil has high salinity and requires an adequate amount of sunlight during the year which may be impacted due to changes in the weather. I would like to evaluate this further by working closely with the local Krishi Vigyan Kendra (Agriculture Centre) and identify key steps to prepare a healthy soil.
- Management of Pests and Diseases: Pests like stem borer, army worm. leaf folder, brown plant hopper, land crab and diseases like bacterial leaf blight and blasts are the major pests and diseases observed in coastal saline soils. I would like to understand the process for surveillance and monitoring the pest population and timely diagnosis and need based application of bio pesticides.

- Make the App vernacular through offering it in local languages (Marathi and Hindi) so that it can reach all the local farmers.

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