System Analysis

Team Members

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2. Requirement Analysis

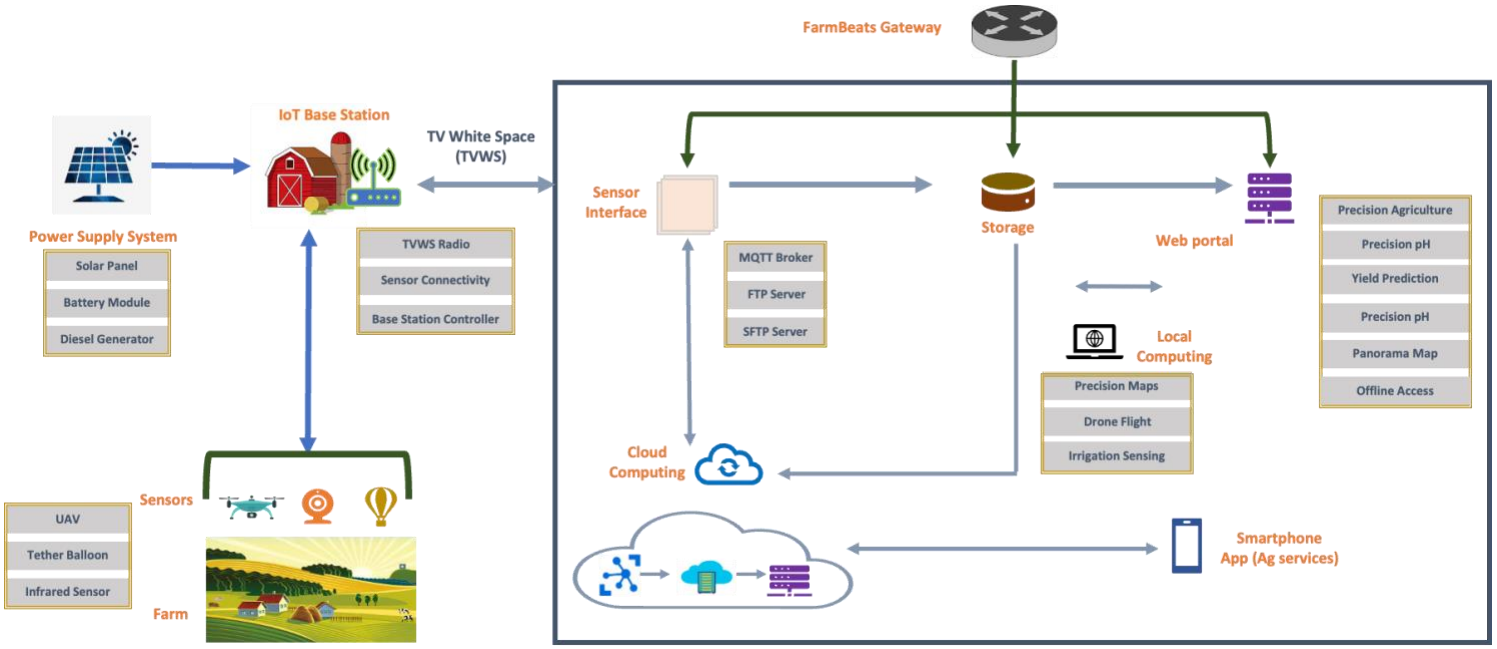
(a) Write up at least 10 L0 requirements for the project and from them, derive as many L1 requirements.

S	Lvl	Lvl	Requirements	Type
1	L0		It shall be able to map the farm using a drone, camera and other sensors.	M
		L1.1	It shall create a panoramic map with data received from sensors and predicted by the system.	M
		L1.2	During mapping, capturing systems shall not leave any blind spots.	M
2	L0		Array of Sensors shall monitor and transmit data to the server.	M
		L1.1	Data shall be end-to-end encrypted.	M
		L1.2	All the sensors shall be calibrated to report similar values for similar conditions.	M
		L1.3	These shall have on-board diagnostics capabilities.	M
		L1.4	These shall not show any performance deviation when subjected to harsh weather conditions.	M
3	L0		It shall provide both online and offline mode of data access.	M
		L1.1	It shall have a web portal to access the data.	M
		L1.2	It shall provide information in standard units wherever applicable.	M
		L1.3	It shall information like pH, moisture, and temperature mapping.	M
		L1.4	It shall show a panoramic map with data received from sensors and predicted by the system.	M
		L1.5	It should provide information on which part of land is unavailable due to obstruction like water puddles.	M
		L1.6	Data shall be visualized on the portal in non-technical way to make it easy to interpret by the farmers.	Non
4	L0		User shall be able to access relevant information through mobile application and the web portal.	M
		L1.1	User shall get notification about any urgent action which is required. Urgent action implies, any irregularity in sensor data, any harm to cattle on the farm.	M
		L1.2	More uses to be identified during the development process.	Non

		L1.3	Data shall be visualized on the portal in non-technical way to make it easy to interpret by the farmers.	Non
5	L0		It shall monitor moisture content of the soil.	M
		L1.1	It will use a scale of 1 to 5 to display the data.	M
		L1.2	Color map should provide clear distinction between the different levels.	O
		L1.3	It shall automatically upload the captured data to the cloud.	M
		L1.4	It shall provide data on-demand, whenever requested through the web portal or the mobile app.	M
6	L0		It shall monitor pH level of the soil.	M
		L1.1	Accuracy of pH sensor shall be 0.1 pH.	M
		L1.2	Precision of the display shall be 0.1 pH.	M
		L1.3	Color map should provide clear distinction between the different levels.	O
		L1.4	It shall provide data on-demand, whenever requested through the web portal or the mobile app.	M
		L1.5	It shall automatically upload the captured data to the cloud.	M
7	L0		It shall monitor Temperature of the soil.	M
		L1.1	It shall provide display precision of 0.1 °C and 0.1 °F	M
		L1.2	It shall provide accuracy of 1 degree.	M
		L1.3	It shall automatically upload the captured data to the cloud.	M
		L1.4	It shall provide data on-demand, whenever requested through the web portal or the mobile app.	M
8	L0		It shall provide 24/7 power availability without any gaps.	M
		L1.1	It should use combination of renewable and non-renewable energy resources for fulfil the energy requirements of the system.	M
		L1.2	It shall have an alternate mode (other than electricity from grid) of power backup in case of emergency failure.	M
		L1.3	It should be able to provide backup for up to 48 hrs. with reduced system functionality.	M
9	L0		It shall ensure data transfer to cloud and base station without any gaps.	M
		L1.1	In case of outage, it shall be able to transfer data to local storage.	M
		L1.2	Communication channel shall be active for duration more than required for transfer of data.	M
		L1.3	Data should be processed locally and summary should be transferred to cloud.	M
10	L0		It should provide good strength of communication across the farm and relay stations.	M
		L1.1	To put things to perspective average farm size in Punjab is 0.362 sq kms. It shall factor other parameters like data relay from the farm to base station, or to any relay station which is established.	M
		L1.2	It should use TV white space for data transfer.	M
11	L0		Drone shall have optimized path planning algorithm to cover the farm with high accuracy.	M
		L1.1	Path should cover all the sensors placed in the farm.	M
		L1.2	It should factor environmental conditions like wind velocity in the algorithm.	M

12	L0		All the systems deployed in the farm shall be weather proof.	M
		L1.1	Systems shall be dust proof.	M
		L1.2	Systems shall be water proof.	M
		L1.3	Systems should be equipped with lightening arrestor.	M

(b) Draw and label a schematic of the system structure.



(c) Describe the system inputs and outputs.

Inputs to the system:

1. **Soil sensor data:** This data is collected through array of sensors placed at strategic location in the farm. It includes information like moisture content, pH, and temperature. These data points will be monitored continuously and transmitted to base station and server without any outage.
2. **Image captured by drone:** These inputs will be combined with data received from the sensors to create meaningful interpretation for benefit of the farmers. Drone captures multiple images of the farm and then, these will be stitched to create a mosaic. These acts as input to creation of pH, temperature, moisture and overall map of the farm.
3. **IR images:** These images will be captured by the IR transmitter-camera pair mounted on the drone. Information received from this will be used in creating maps explained in the last section.
4. **Power Supply:** These will be available in multiple form which includes combination of renewable and non-renewable energy resources.

5. **Weather and Price info from the cloud:** These will include data about weather condition and forecast collected from meteorological department. It will be used in suggesting action required for improving productivity and profitability of the farms.
6. **Control instruction from remote station:** These are inputs received from the operator at base station, through mobile app or the web portal.
7. **Farmer's feedback:** System implements a robust feedback mechanism to support continuous improvement of the system parameters. This will serve as crucial input parameter to identify the malfunctioning of different components of the system.

Outputs of the system:

1. **Crop Suggestion:** Based on data collected from multiple data collection points like sensors, drone and meteorological information, system will generate suggestion on crops to plant to achieve maximum productivity and profitability.
2. **Where to sell the farm produce?**
3. **Irrigation and crop state alerts:** It will generate suggestion on time to irrigate, put fertilizers, and pesticide. It will also provide information on harvesting of the crops.
4. **Seed Distribution Pattern:** This will be generated to inform the farmer about how shall he/she plan the seed distribution across the productive farm areas.
5. **Yield Monitoring:** System monitors the data point to create a yield map for whole farm. It will help understand the productivity capability of the particular patch of land. In case, some patch is producing below expected productivity, system will provide suggestion on how to improve it.
6. **Notification on safety of farm animals:** System monitors and generates notification if any farm animals are crossing safe zones identified in the farm. This includes monitoring the animals if they are close to electric fence or any other fence which can harm them.
7. **Precision agriculture:** System will generate precision maps of pH, moisture, temperature etc. to implement precision agriculture at every location of the farm.
8. **Virtual Walkthrough:** System will generate 3D map of the farm areas. User can any point of time can check these at the web portal.
9. **Productivity Apps:** Both web portal and mobile app will feature productivity application which uses data collected to support smooth functioning of the farm ecosystem. For example, managing farm-based expenses and liabilities.
10. **Storage monitoring:** It will have integrated storage monitoring system. This will aid the farmer in keep pace with materials which he needs to procure, which is getting wasted due to expiry or bad weather.
11. **Cow Shed Monitoring:** it will have integrated cow shed monitoring system.

(d) Describe the system boundary. What things will be outside the boundary, what things will be inside the boundary?

Answer: However, system attempts to act as one-stop solution for all the farmer's needs but it is not possible to incorporate everything because of multiple reasons including logistics and operations.

Following remains outside the system scope:

1. **Weather:** System has no control on weather conditions. It should try to cope with scenarios created by weather.
2. **Predators:** However, system tries to provide information on any risk posed by predators like insects, cattle etc. but control of these parameters remain outside the scope.
3. **Natural calamity**
4. **Seed quality:** Procurement of high-quality seeds. Farmer should monitor and ensure the quality.
5. **Material procurement:** Procurement of any materials like fertilizers, seed, shed material, to support farming is farmer's responsibility.
6. **Fencing:** Type of fencing and its operation
7. **Irrigation system**
8. **Farm equipment** like tractors, implements etc.

Following will be considered inside systems scope:

1. Data Collection via sensors, drones and camera
2. Data Processing at the FarmBeats gateway
3. Data Interpretation
4. Prediction on parameters of productivity and profitability.
5. On-farm Infrastructure
6. Sensor selection and interfacing
7. Drone's flight planning and operation
8. Cloud infrastructure and maintenance
9. Precision agriculture infrastructure like irrigation setup
10. Power supply
11. Base station
12. Storage of data
13. Web server
14. Mobile app and web portal

(e) **Briefly describe how elements in the systems structure will support elements of the system behavior.**

Behavior	Subsystems	How it supports?
Data acquisition	Drone, Camera, IR Camera, Sensors, Base station	Farm state ☞ Sensor system ☞ Base station. Drone will act as a medium.
Data Processing	Local computing, cloud	Data processing will happen at local computing system and cloud
Data Transmission	Base Station, cloud, sensor interface, local computing, storage, mobile app	1. drone system 🤝 base station 🤝 Sensor Interface 2. Sensor interface ☞ Cloud 3. Storage ☞ Cloud 4. Local computing 🤝 Cloud 5. Mobile app 🤝 Cloud 6. Storage 🤝 web portal
Data storage	Local storage, cloud	Data will be stored in both local and cloud storage.
Insights generation	Local computing, web server, cloud	Insights will be generated at local computing and can be accesses through web server and cloud. information
Insight Display	Web portal, Mobile App, cloud	1. Cloud ☞ Mobile app 2. Cloud ☞ Web portal
On-demand information	Mobile app, cloud, web portal, web server	Information can be accessed through web portal and mobile app
Feedback	Mobile app, cloud	User can give feedback through mobile app and web portal.
24/7 operation	Power supply, backup supply	Backup supply will support in case of power supply outage or failure.
☞ one way communication, 🤝 two-way communication		

3. Community of interest

Country: India
State: Punjab
Crops: Wheat**,** Rice, cotton, sugarcane, millets
Population: 27.98 million
Export crops: Basmati Rice

Status of Technological Infrastructure:
Punjab was the center of Green Revolution which happened in India during the late 1960s. Since then, it has not seen significant inclusion of technology in farm practices. Hence, current agricultural infrastructure doesn't support sophisticated technologies like robots, drones, satellite communication, cloud connectivity, Data driven agriculture etc. The Punjabi farmer has found it hard

to escape the whirlpool of an ecologically unviable cropping pattern and its commercial entrapments created by the history of its past six decades. Considering their potential to growth and their prowess in agricultural developments, it is our choice of the community.

4. Stakeholder Analysis

4.1. Stakeholder Identification

4.1.1. Internal Stakeholders

1. Management Team
2. Engineering - Sensors Interfacing
3. Engineering - Azure Cloud and Storage
4. Engineering - App development
5. Engineering - Testing and Quality assurance
6. Engineering - Power Supply Engineering
7. Engineering - Communication Systems
8. Engineering - Flight planning and data acquisition
9. Operations - Includes Program Management
10. Field Maintenance
11. Server Maintenance
12. Customer Support
13. Component Management and Material Sourcing (CMMS) - Liaison between multiple teams.

4.1.2. External Stakeholders

1. Farmer
2. Journalists
3. Environmentalists
4. Consumer to Farmers.
5. Financers to Farmers
6. Insurance Provider
7. Farm Animals - e.g., Connected Cow.
8. Material suppliers - Seed, Fertilizer, Pesticide etc.
9. Agricultural equipment supplier-Shed Materials, Precision farming equipment (irrigation etc.).
10. Stakeholders to the Farmer: Distributors, Transportation

4.2. Stakeholder Analysis

Power/ Influence					
	High	Watch	Keep Satisfied	Actively Manage	Type
				Management Team	**Int.**
		Financier, Insurance provider		Farmer	**Ext.**
	Some	Keep on side			
		Server Maintenance	Operations, CMMS, Customer Support	Engineering: All teams	**Int.**
		Stakeholder to Farmers	Agricultural equipment, Material supplier.		**Ext.**
	Little	General Comm.	Keep Informed		
			Field Maintenance		**Int.**
		Farm animals	Journalists, Consumers to farmers	Environmentalists	**Ext.**
		Little	**Some**	**High**	
		Interest			
Abbreviation: Int. – Internal, Ext. – External, Comm. - Communication					

Stakeholder allegiances

Assessment	Who?
Advocates (A)	Management Team, Financiers
Followers (F)	Engineering Team, CMMS, Operations, Customer Support, Farmer, Server maintenance, Field maintenance
Indifferent (I)	Farm Animals, Journalists, Consumer to Farmer, Stakeholders to Farmers, Agricultural equipment and material supplier.
Blockers (B)	Insurance Provider
Opponents (O)	Environmentalist

4.3. Stakeholder Management Strategy

Stakeholder	Impact	Impor.	Alleg.	AIH	LIH	HIH	MIH	Concerns	Actions
Internal stakeholders									
Management Team	High	High	A				Δ	Profits & Market capturing	Continuous updates and forecast
Engineering Team	High	High	F			Δ →		Stable functioning of the system	Budget surety, clear requirements
Operations	Med	Med	F			Δ →		Timelines and efficient day to day operations	engagement from beginning
CMMS	High	High	F			Δ →		Ontime delivery and quality assurance of the components.	Identifying robust supply channels, engagement from beginning.
Customer Support	Med	Med	F			Δ →		Customer has limited background	more interaction with farmers during development
Server Maintenance	Med	Med	F			Δ →		System outages and large amount of data	Backup power supplies and storage
Field Maintenance	Med	Med	F			Δ →		Remote locations	Appropriate lodging & transportation
External Stakeholders									
Farmers	High	Some	F		Δ →			Transparency, privacy and cost	Workshops, collaboration with NGOs.
Financiers	Med	High	A		Δ →			Unsure ROI	Provide exhaustive market insights
Insurance company	High	High	B	Δ →				Unforeseeable new circumstances	Revaluation of contract terms and premium at regular interval
Material Supplier	Med	High	I		Δ →			Amount of material needed	Fixing BOM at early stages.
Stakeholder to Farmer: Distributors, transportation…	Med	Little	I		Δ →			Ability to meet demands and quality requirements	To provide Quality and quantity info.

Farm Animals	Low	Some	I		Δ	→		Freedom of movement, pasture areas.	Adjustable boundaries & connections
Journalists	Low	High	I		Δ	→		Is something fishy?	Regular sync-up & demonstration
Consumer to Farmer	Low	Some	I		Δ	→		Quality of the produced materials	Conveying positive impacts via media channels
Environmentalists	Med		O	Δ	→			Impact on environment?	Regular sync-up & demonstration, adopting sustainable techs.

Impor. = Importance, **Key:** AIH – Against it happening; LIH – Let it happen; HIH – Help it happen; MIH – Make it happen, Alleg. – Allegiances

5. Real World Constraints

See the following link: https://labs.ece.uw.edu/community/RWC/

(a) What might be the social and ethical challenges of your project?

Overall social construct of society in India may feel challenging during implementation of the project. As the farms are more driven by traditional methods of farming. However, Punjab has shown tremendous interest in adopting technology in their farming practices. We may encounter following challenges during implementation:

1. As digital practices are still waiting for adoption, there will be concern on misuse of private data.
2. As the data collected will be in direct control of corporate, there will be concerns about unethical control in crop selection. Farmer might be worried that they are being feed with information to drive some propaganda.
3. The project may face significant challenges by slow adoption of modern technological expertise.
4. In continuation of point 3, it will offer a steep learning curve while adoption of the tech.
5. As mentioned earlier, farmers tend to trust traditional methods and developing trust in tech will be BIGGEST challenge for the project.
6. One of the major challenges will be faced by availability of power supply from grid. It may have impact on functionality of the system. As mentioned in requirement, we need backup power supply to address those scenarios.

(b) What are the economic challenges for your project?

Some of the major economic challenges are as below:

1. As mentioned in answer to previous question, as Punjab lack on some of the infrastructure required for the project. It will result in high cost of infrastructure, maintenance and deployment.
2. There will be impact on cost which comes with training of the farmers. It will include training on:
    a. Understanding precision agricultural insights provided in the app.
    b. Understanding warnings related to system failure / cattle moving out of safe zone, Warehouse and storage statistics.
    c. Understanding methodology for reporting feedback.
3. New insurance contracts need to be drafted due to changes in the farm dynamics. This type of infrastructure will be new to farmers, as well as insurance providers.
    a. Due to the potentially uncertain nature of the insurance providers to the farmer, we might need to introduce insurance via third party affiliation (potential increase in overall system cost).
    b. It can help increase farmer's trust in the system and eventually help in streamlining equipment deployment.

(c) How do the above economic and socio-ethical challenges limit or steer technical design?

These economic and socio-ethical challenges will drive the overall project viability and direction.

1. Low purchase power parity in the community will be an issue. If we compare income (in terms of PPP) of American farm to farmers in Punjab, farmers in Punjab have significantly less PPP. Exact figure of Punjab is between $5k-$10K while in America it is >$60k. (for details, this link can be referred: Link). This issue will drive the project towards low-cost solution for the systems.
2. This may have impact on the functionality of the sensors and other systems part of the system.
3. It will also ask to develop new training and delivery methodology.
4. As mentioned, Trust will play a major role in adoptability and these considerations must be factored at very beginning of the project.

above challenges may create some hinderance in large scale implementation.

(d) If you could change one aspect of the system, what would it be and why?

One of the major problems highlighted in discussions above is increasing "Trust" in the system. Considering all the social, and economical behavior of the community, we may fail to convince farmer on the how data is being used in the background. They will be worried about price and crop manipulation.

Right now, farmers have very less control over the system and their data. Company owns the full rights over how to use the system and the insights derived from it. There are no checks over the recommendations provided by the company to the farmers. This can lead — in the worst case — to price manipulation of the agricultural market making farmers and consumers worse off than before even after taking into account the increased productivity of agricultural sector as a whole.

The trust issues can be handled by implementing following in the system:

1. **Data safeguarding solutions like End-to-end data encryption can be implemented.**
   This will help in making them feel safe about protection from data tampering by third-party entities.

2. **Data access monitoring tools, and data anonymization might be required.** It will increase the software complexity but will help in bringing more transparency to the system.

3. **Oversight board might be required to ensure judicious use of data.**
   This board can be monitored by stakeholders like govt. or NGOs working for welfare of the farm. As this is monitored by entities, to whom farmer are already familiar, they will have more confidence in the system.

(e) How will the changed system compare to the original system? [You can recommend additions or limitations to the project scope, change the requirements, stakeholders, project description, etc. Think about what you would change if you were in charge of this effort].

New system when compared to original system will find differences on below points:

1. It may or may not have impact on quality of the equipment.
2. We might need to look into reduction of services and functionality offered by the original system.
3. Addition of state and national govt. as external stakeholder might be a possible solution. As, this stakeholder addition can result in subsidies to farmers in setting up the infrastructure including material, equipment and service cost.
4. Addition of this stakeholder will lead to additional efforts to create alignment in expectation. If both state and national government are included, there might be clashes in their political motives. So, selection has to be done significant due diligence.
5. It may ask for seeking collaboration with local companies and NGOs to use their skills with locals to develop trust among them.