W04L01: Crop Residue Management

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Status of Crop Residues in India

- Approximately 700 million tonnes crop residues are produced in India on annual basis

- Cereal group (Rice, Wheat, Maize, Pearlmillet, Barley, Small Millets, Sorghum) produce the highest amount of 368 million tonnes (54%) followed by sugarcane 111 million tonnes (16%)

- At individual crop level
  - Rice contributes highest (154 million tonnes)
  - Followed by wheat (131 million tonnes)

Status of Crop Residues in India

- **State-wise: the generation of crop residues**
  - Uttar Pradesh (approx. 60 MT) highest
  - Punjab (approx. 51 MT)
  - Maharashtra (approx. 46 MT)
  - West Bengal (approx. 36 MT)
  - Bihar (approx. 30 MT)
- **Surplus crop residues (234 MT)**
- Rice (43.5 MT)
- Wheat (28.4)
- Sugarcane (55.7)
- Cotton (46.9)

(Source: Hiloidhari et al., 2014)

Burning and its consequences

- Emission of greenhouse gases (GHGs)
- Releases Particulate Matter (PM) and smog which pollutes air
- Killing of beneficial soil microbes
- Loss of soil nutrients

Crop Residue Burning in India (Approx. 100 MT) releases

- 8.57 Mt of CO
- 141.15 Mt of CO_2
- 0.037 Mt of SO_x
- 0.23 Mt of NO_x
- 1.21 Mt of PM

(Source: Bhuvaneshwari et al., 2019)

Machines for CRM

- ✓ **Combine harvester with SMS**
- ✓ **Happy Seeder** (used for sowing of crop in standing stubble)
- ✓ **Zero till seed drill** (used for land preparations directly sowing of seeds in the previous crop stubble)
- ✓ **Baler** (used for collection of straw and making bales of the paddy stubble)
- ✓ **Paddy Straw Chopper** (cutting of paddy stubble for easily mixing with the soil)
- ✓ **Reaper-cum-Binder** (used for harvesting paddy stubble and making into bundles)
- ✓ **Mulcher**

Value Added Products and other uses

- Animal feeds
- Electricity production
- Mushroom production
- Biochar
- Inert Material for Bio-fertilizer

- Mulching
- Preparation of souvenir
- Plates & Packaging material
- Ethanol Production

Challenges in Crop Residue Management

- Use of combine harvester without SMS
- Transportation cost
- High volume
- Scarcity of labour especially during the season
- Short window between two crops
- Lack of economic viable options

W04L02: CASI Scaling: A System Approach

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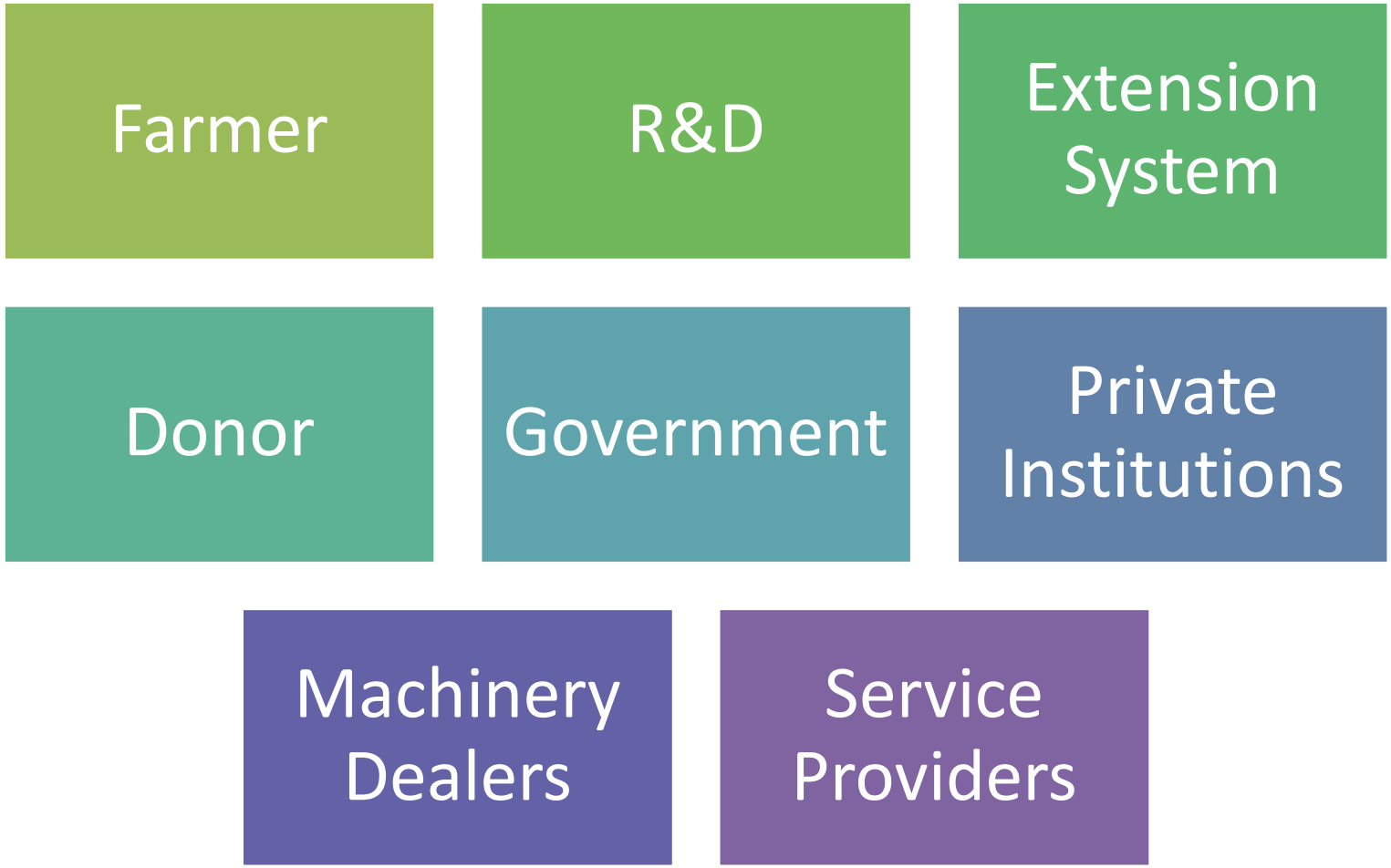
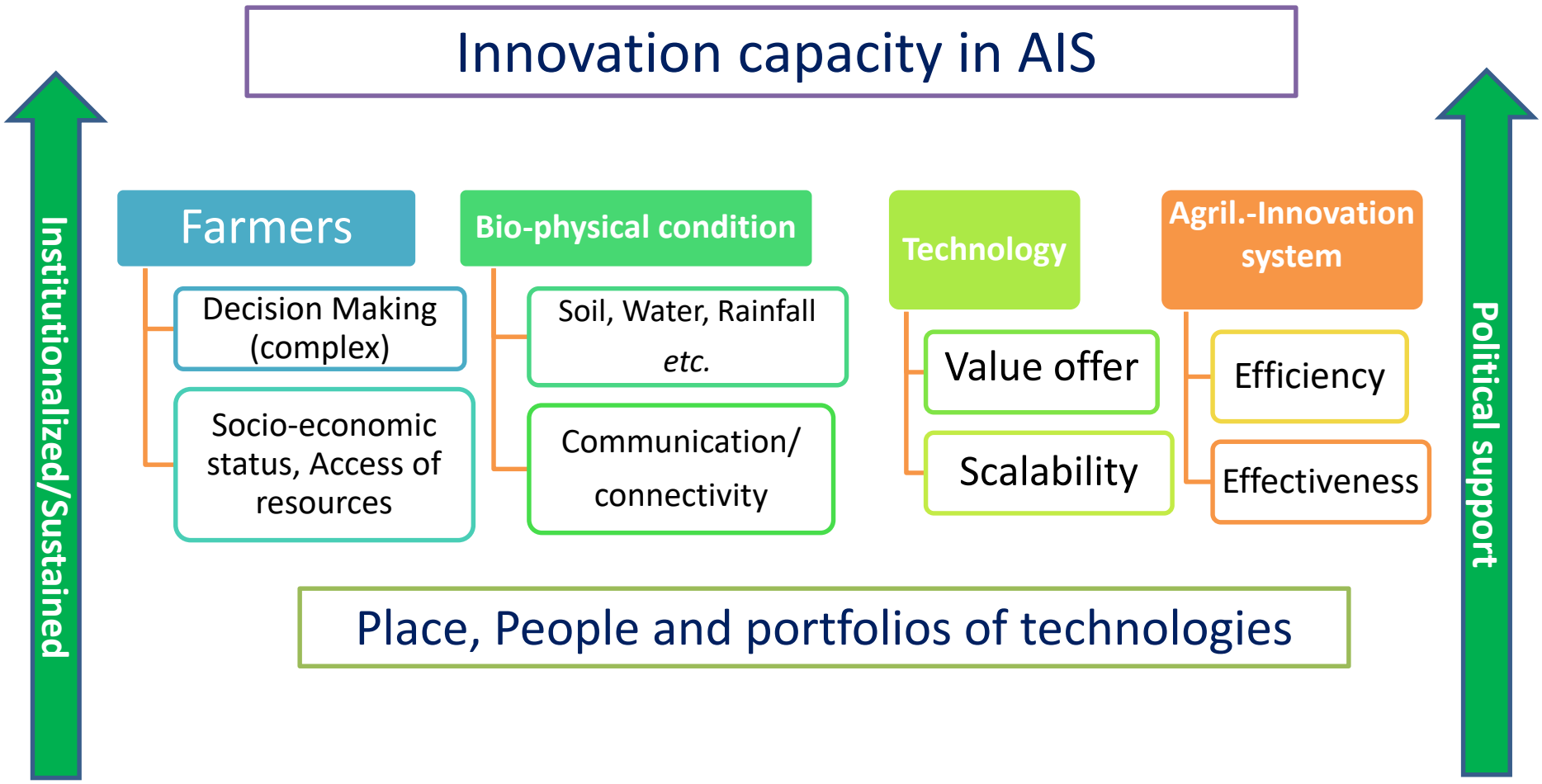
Lack of Convergence



Scaling out framework



Challenges in Scaling of CA

- ✓ Understanding the system
- ✓ Farming System perspective
- ✓ Technological Challenges
- ✓ Long-term research perspective
- ✓ Building relationship
- ✓ Crop residue burning
- ✓ The wide spread use of crop residues for livestock feed and fuel
- ✓ Lack of knowledge about the potential of CA to leaders, extension professionals and farmers
- ✓ Capacity Development

W04L03: Social-Behavioural Challenges

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Some logical questions…

- If CASI portfolios are really good, why we are unable to cross take off point?

- If adopter farmers are appreciating these technologies then why they are not adopting these technologies in their whole land?

- Why Service providers are not purchasing zero tillage machines?

- Most of the time we are pushing CASI technologies, why not they are approaching us ?

Beyond Homo Economicus

- We humans behave in complex ways.
- Farmer ➡ Technology ➡ Channel ➡ Social System
- Roger's model
- We try to make rational decisions
- Bounded rationality

Behavioural Economics

- ✓ Nudge + Demonstration
- ✓ Heuristics
- ✓ Cognitive Bias
- ✓ Social Norms
- ✓ Social Influence
- ✓ Loss aversion

- ✓ Irrational Decision/Misbehaving
- ✓ Dual system theory
- ✓ Innovativeness
- ✓ Recognition
- ✓ Altruistic behaviour

W04L04: Access to CASI Machineries

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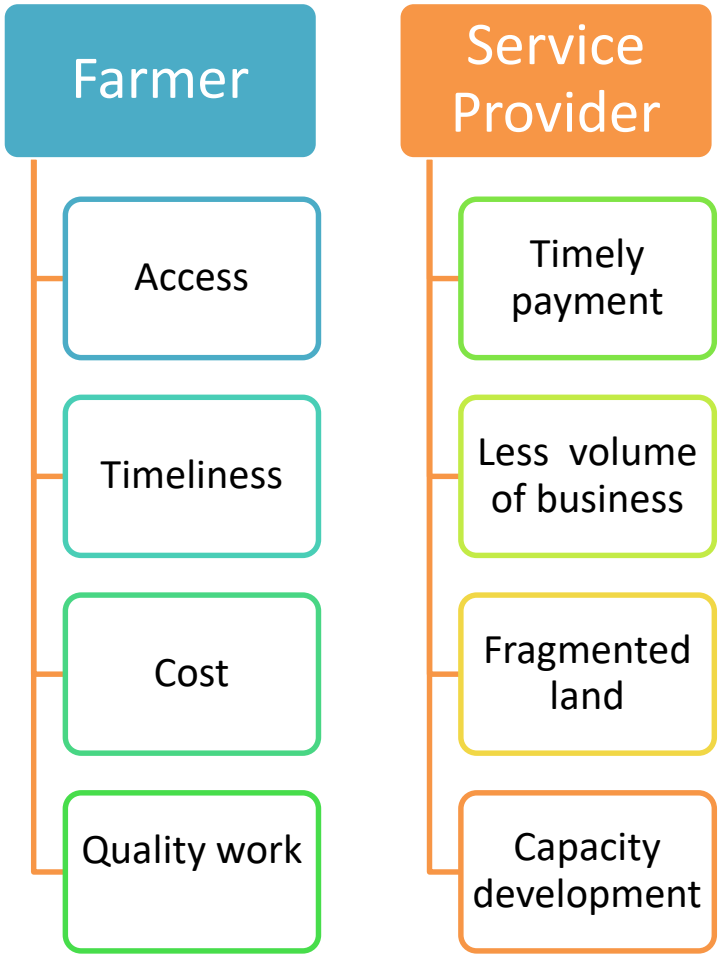
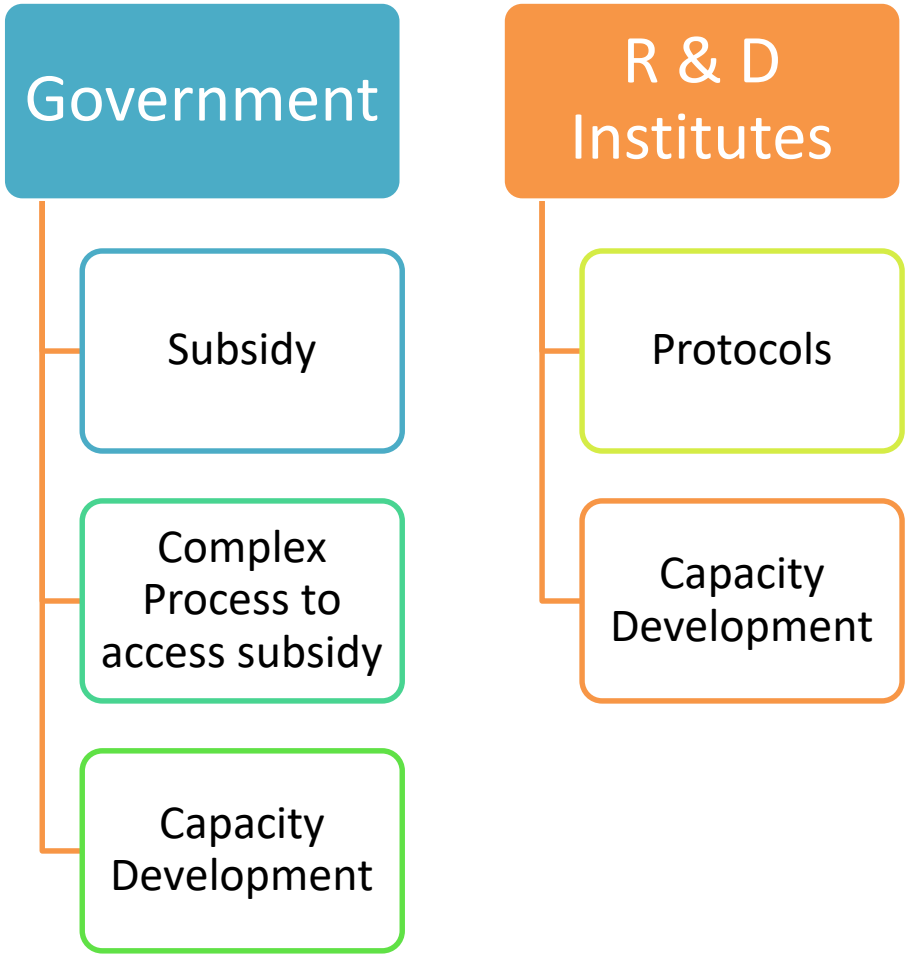
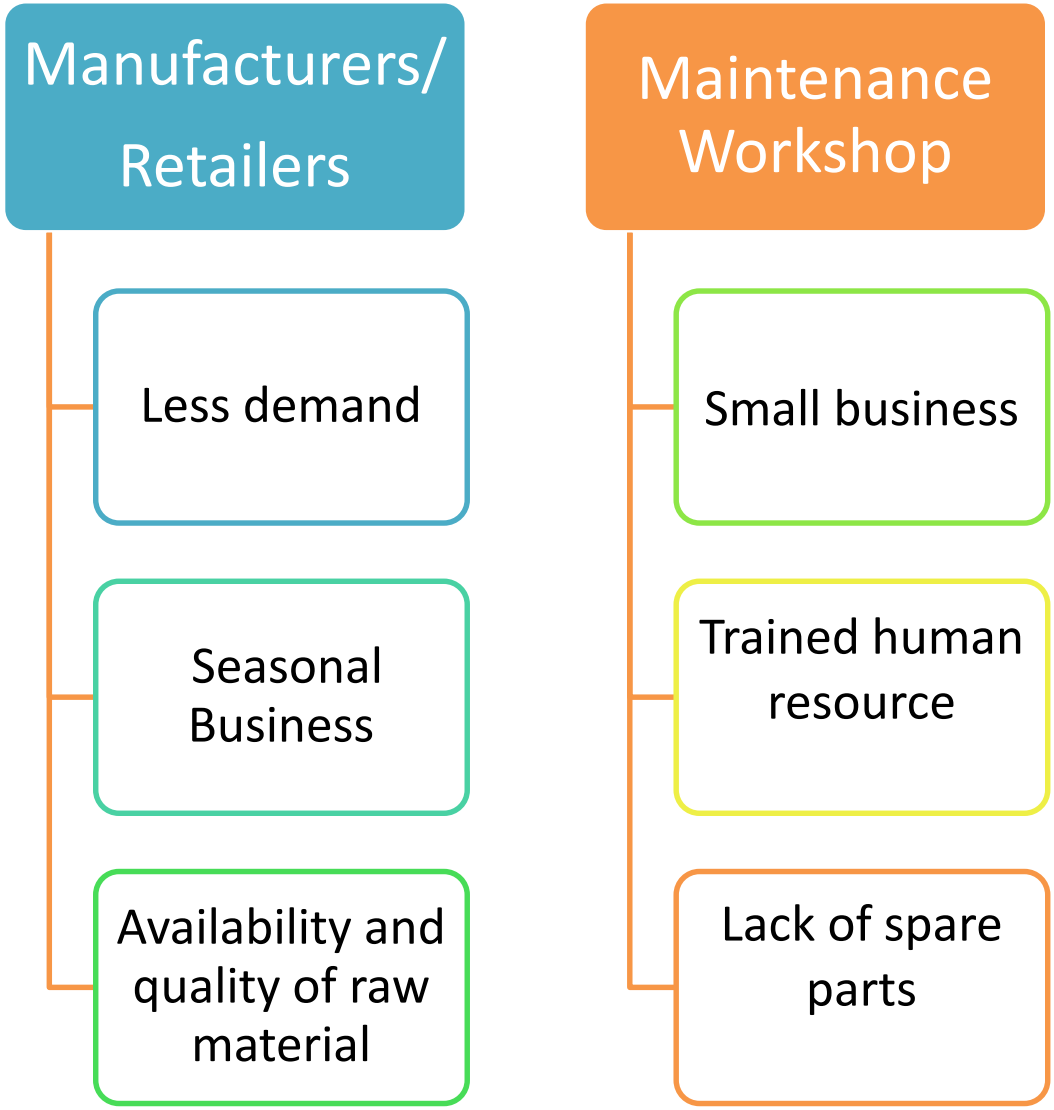
Value Chain of CASI Machineries



Value Chain of CASI Machineries



Value Chain of CASI Machineries



Potential solutions...

- ✓ Scaling of CASI
- ✓ Custom hiring centre
- ✓ Farmers' Club
- ✓ Start-ups
- ✓ Skilled human resource

Course Name: Conservation Agriculture based Sustainable Intensification
Week 04-Lecture-1: Crop Residue Management
Course Instructor: Dr. Ram Datt, Assistant Professor-cum-Jr. Scientist (Extension Education), BAU, Sabour

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Namaste friends. Modern day agriculture has been made easy with the use of agriculture machines and tools. But the use of certain machines has also created some problems. The combine harvester is one such machine as it leaves behind crop residue after harvesting. Now, a lot of farmers are in a hurry to plant the next crop so they burn the crop residues and that creates a lot of problems.

Today, we will talk about crop residue management. India produces around 700 million tons of crop residue. Now, food crops like wheat, rice, maize, bajra, jowar and others contribute around 368 million tons of crop residue which comes around 54% of the overall crop residue produced. Sugarcane produces around 111 million tons of crop residue and this is 16% of the total crop residue generated.

Individually, rice produces around 154 million tons of crop residue, wheat produces 131 million tonss of crop residue. In terms of provinces, Uttar Pradesh contributes the most with 60 million tons of crop residue. Next is Punjab which produces 51 million tons of crop residue and third is Maharashtra which produces 46 million tons of residues. West Bengal produces 36 million tons and Bihar produces around 30 million tons of crop residue.

Out of the 700 million tons' crop residue produced, around 234 million tons of crop residue is surplus. Individually, rice produces around 43.5 million tons of surplus, wheat contributes 28.4 million tons, sugarcane produces 55.7 million tons and cotton producers around 46.9 million tons of surplus.

The farmers in our country burn around a 100 million tons of crop residue in our farms which creates a lot of problems. As a result of residue burning, greenhouse gases are emitted in the environment. Also, the beneficial microbes in the soil die and we lose soil nutrients. Additionally, there is deterioration of air quality.

Burning around 100 million tons of crop residue produces 8.7 million tons of carbon monoxide, 141.15 million tons of carbon dioxide, 0.037 million ton of Sulphur oxide, 0.23 million tons of nitrous oxide and around 1.21 million tons of particulate matter. Besides these, many other poisonous gases are also produced which pollutes our environment.

Now to manage crop residue, there are many machines available. The foremost advice given to farmers is to attach a straw management system to their combine harvester. The second most helpful machine is a Happy seeder for crop residue management. We can use the Happy seeder machine if there is a lot of crop residue in our farm and it is not possible to use a zero till machine. If the crop was cut properly then after using a baler we can use a Zero Tillage machine.

We can also use a paddy chopper. It cuts the crop and mixes it in the soil. There is another machine called reaper combiner that cuts the crop and then also binds it together. Another machine called mulcher is also a useful machine in crop residue management. There are many additional machines that are available which can facilitate the management of residue in our farm.

Crop residue can be used to produce many different products and has many beneficial uses. In India crop residue is mostly used as a fodder for livestock. But paddy straw has less quantity of crude protein and also has issues with digestibility. So if we treat the paddy straw with urea, then it increases the quantity of

crude protein and its digestibility. For 100 kg of feed, 4 kg of urea is sufficient and we can make our feed useful.

Also, these days using crop residue to produce electricity is being tested. The Punjab government has established four or five such units. But if this is useful or not is still up to debate.

Paddy and Wheat straw is also used for mushroom production. It is said that with 1 kg of residue, we can produce around 1 to1.15 kg oyster mushroom or 700 to 800-gram button mushroom.

We can also use the residue as an inert material in bio fertilizers. Now, mostly talcum powder, charcoal or fly ashis used as an inert material. Charcoal is considered the best material as it has two beneficial traits. The water holding capacity of inert material should be more than 40% and its size should be between 0.15 to 0.21 mm. If these two qualities can be created for crop residue, then we can use this as an inert material for bio fertilizers.

In addition to the above, we can also use crop residue as bio jar. We also use crop residue for mulching in vegetable production. Crop residue was successfully used to produce souvenirs by ladies in Jehanabad and these souvenirs sell for good money. Crop residue can be used in the form of business. Some Delhi based startups have used the crop residue for packaging material and plates. We can also use it in vermicomposting. Finally, in India, ethanol production is being contemplated and how ethanol can be produced using crop residue.

So there are many uses of crop residue and the main thing is that we have to make these options economical.

In the end we now look at the problems in crop residue management. The biggest problem is that if we use a combine harvester without the straw management system then it is very difficult to manage the crop residue. The second problem is the transportation cost of moving crop residue from one place to the other. Crop residue is produced in great volume and it is expensive to transport. Also, the time frame between harvest and sowing the next crop is small so many times farmers are in a hurry and they decide to burn the residue. Finally, a lot more research needs to be done so that we can make crop residue management and alternate use economical so that farmers can easily adopt it.

In the end, I would say not to burn the crop residue as it can be a very useful value added product and also an additional source of income. By doing this, we also keep our air clean.

Course Name: Conservation Agriculture based Sustainable Intensification
Week 04-Lecture-2: CASI Scaling: A System Approach
Course Instructor: Dr. Ram Datt, Assistant Professor-cum-Jr. Scientist (Extension Education), BAU, Sabour

Namaste, friends. If we want farmers to adopt a particular technology, then even a small mistake can hinder its spread.

There can be many reasons for a technology not spreading. We might be a research and development institute and focus solely on technology but due to lack of proper infrastructure, the technology fails to become popular. It can also be that we are a government institute that provides subsidies or financial support or machinery but because of not following proper protocol, the technology fails to spread. Or we might be a donor who is running a research program, then the agency through which we are working has an important role to play.

So the main reason why any technology is not adopted is because we do not look at it as a system approach. CASI is a system approach and its scaling is a system. The different stakeholders like the farmer, government agencies, research and development institutes, donor, private institutions that manufacture machines and service providers should have communication between each other and they should know what role they play and who can play what work efficiently. It is because of lack of communication between the various stakeholders that the adoption of technology is very slow or it does not take place.

To understand it better, we will now discuss the scaling framework and who are the different stakeholders and how we can improve this whole process.

The adoption process is also affected by the socio-economic condition of the farmer, access to resources, gender and his entitlement to land.

Besides this, the decision making process of a farmer is a very complex process. It is simplistic to think that he will adopt the technology by just looking at the economic perspective. The farmer while deciding which technology to adopt keeps in mind the biophysical condition of his farm, his soil, water availability, rainfall pattern and connectivity.

The nature of technology we are offering and the relative advantage that it offers over the technology that is currently in use also plays an important role in a technology adoption. The value offer of this new technology should be better than the current technology in use like it should increase yield or it should lower cost of cultivation.

Next, we also have to consider the scalability and the things that are required for the successful diffusion of a technology. An example can be the lack of infrastructure like in every village there should be at least one machine. But with just one machine, the technology can be adopted only within a limited area. So the adoption process might get halted by the lack of infrastructure.

Now looking at the entire process of diffusion of a technology in a systems perspective, we have to look at the role of different stakeholders. The research and development institute can improve their prototype, capacity development of stakeholders can be improved, the government needs to develop the

infrastructure, the donors should support research programs and the private institutions need to provide quality machines and inputs.

All this depends on two factors. The first is how we can make this process effective with least resources. The second is that we have to see what is the right role for whom and according to that we will have to strengthen the convergence process. Once we have created the system then we would have to institutionalize or formalize it and then it would become stable. We require political and government support to achieve this. So CASI is an agriculture innovation system and the role of place, people and portfolio are very important.

Now, we look at the challenges in the scaling of CASI. In the first week we looked at some practical issues. Now, we will look at other issues. First, many times we do not understand the system and because of that our scaling process goes slow. We have to work in the farming system perspective and identify people's problems and their local situation. We have to work together with the people and move forward the participatory technology development process or demonstrations. The third is technological challenges like because of not having proper protocol we do not get germination or there is a lot of weed infestation or many times there is crop failure as a result of which the trust of farmer breaks and it becomes very difficult.

In conservation agriculture there is also the problem that we do not at times see the results immediately. For example, we say that conservation agriculture will improve our soil health. But for that we have to do crop residue retention for a long time and then we can see the improvement in soil health. So at times a long term perspective can come up as a challenge.

We have to develop convergence and trust between different stakeholders. Many times due to lack of trust, the stakeholders work in different directions and this slows our adoption and scaling process.

Recently, the burning of crop residue has come out to be a major problem. Farmers burn the crop residue in the farm itself as the window from the harvest and sowing of the next crop is very small.

Additionally, there is also the problem of using crop residue as fuel and fodder. So if we are advising farmers to do more and more crop residue retention then we have to understand that crop residue is a valuable product for farmers and they use it as a fodder for their livestock. So we will have to make a balance between all of these things

Government institutions and political leaders also have a role to play in the scaling process. It is very important that they also have some knowledge of the technology.

In the end, we have to do capacity development of all the stakeholder be it the research and development people, scientist, farmers, service providers or anyone associated with the manufacture of machines. Only then will our system be able to run smoothly. This also can be a major reason why technology is not adopted.

So friends, we have to look at adoption as an overall systems perspective. The moment we see it as an isolated sub system like technology, capacity development or knowledge dissemination then our scaling process does not take place as we want.

So our suggestion is that this is a system and we should look at it from a system perspective.

Course Name: Conservation Agriculture based Sustainable Intensification
Week 04-Lecture-3: Social-Behavioural Challenges
Course Instructor: Dr. Ram Datt, Assistant Professor-cum-Jr. Scientist (Extension Education), BAU, Sabour

Namaste friends. We have so far learnt about the benefits of conservation agriculture like how it is less costly, produces more yield, saves time, water and labor. In addition to these, it is also proven that conservation agriculture is environment friendly.

But a question still remains is that despite being so beneficial, why is conservation agriculture not adopted at the rate it should have been. In a social system, why have we not able to achieve the take off point? By takeoff point we mean that any technology, once it is adopted by around 10% to 15% then this technology need not be pushed. Farmers by themselves communicate with each other and adopt this technique.

Some intriguing question that arouses our interest is that if a farmer has 10 acres of farm then why does he do conservation agriculture only in 2 or 3 acres and not in the entire 10 acres. Also, we are pushing the adoption of conservation agriculture but why are farmers not coming by themselves and asking about conservation agriculture and its adoption.

To answer these questions, we would have to understand the adoption process which is a very complex process. The decision making process of people and their behavior is very complex.

If we look at the adoption process, we see that there is a farmer who adopts a technology. Now according to Rogers, this technology should have 5 characteristics i.e. relative advantage, complexity, compatibility, trialability and observability.

Also there is the communication channel or change agent through which our technique is reaching the farmers. It is a social system where the farmer is not alone. There are other people who are influencing his decision.

We know that farmers or anyone else take rational decisions on the basis of information and money available to them. This is called the bounded rationality model.

Now today, we will talk about something that is in addition to the above factors. Besides, age and education of the farmer and technology, there are many more components that influence the adoption process.

We are for the first time going to look into behaviour economics in Eastern Gangetic Plains and aim to find answers about why despite technology being beneficial, people are not adopting it at the desired speed.

From our research, we have found that in addition to providing reminders or nudges to someone, we should also organize demonstrations. Farmers always want to see something first and then trust it. So we just don't have to push the technology but also organize demonstrations or trials.

I want to share a real life example. We were working in Purnea district and I asked a farmer who is considered a large cultivator about why he did not adopt this technique when we initially

started it. His reply was he first wanted to observe it. The field technician would always tell him to come to the trial demonstration plot but he first wanted to try it in a small area and see the result. After finding it is beneficial, he increased the area. So basically, continuous reminders are very important.

Also, we have to understand that while promoting zero tillage, we are telling farmers in a way to not do something that they have been doing since generations i.e. tilling. So we have to share the message with farmers in such a way that they can understand us and adopt this new technology.

Farmers live in a social system and are not alone. They have a family with certain social norms and influences.

I want to share another interesting story with you all. On many occasions, we used to organize a focus group discussion with farmers after crop harvest. We would invite farmers who have adopted conservation agriculture and also those who have not adopted it. The farmers who have adopted conservation agriculture would share the benefits of it and then we would ask those farmers who have not adopted conservation agriculture about why they have not tried it as their neighbors are benefitting from it. So under peer pressure, they would say that they would do it from now and eventually they would actually do it. So we can keep these things in mind while designing the adoption or diffusion process.

Now 90% of the farmers in EGP are small cultivators. If due to some reason their crop fails, then their livelihood will be affected. So they are risk / loss averse. If you tell them to invest 1 rupees promising 2 rupees in return, then they still won't do it. They want to keep doing what they are doing as it is well proven. So you have to instill trust in them that your technology is beneficial and that they are not going to incur any loss because of it.

According to us, many times farmers behave irrationally like whenever we talk to farmers about any new technique, the first thing they ask us is how much more yield can it generate. Seldom, we meet farmers who take into consideration their cost of cultivation. With this technology, we can only get 5to 10 % better yield but there is a lot of cost savings. So many times the adoption of this new technology is not as rapid as we want it to be because farmers concentrate mostly on yield. We have to design our message in such a way that farmers also look into the cost aspect of their cultivation.

For this, there is a dual system theory which says that people make decisions according to system 1 and system 2. The quick decisions that we make without much deliberation like farmers rejecting a technology straight away without much thought will fall under system 1. But system 2 are decisions taken after much thought and deliberation. So we have to bring farmers towards system 2 by making them realize the benefits of this technology.

We have also met farmers who are very inquisitive and ready to adopt new techniques and technology and they want to go to the bottom of things to know what they can do.

Another interesting fact that we discovered during our research was that some farmers initially were not getting very good yield so we asked the farmers the reason for not rejecting this technique when it was not giving the desired results. The farmers told us that they were very happy that scientists and experts from abroad would come to their farm. They would tell others about these visits of foreigners to their farm. This is the reason why we wanted to try it for longer and give it a chance. So recognition also helps in diffusion of technology.

The technology is environment friendly as well. There is also an altruistic side of people. Do you think farmers are concerned about the way they are exploiting their soil and farm? Or if they keep using excess water then water resources would deplete. Or providing more chemical fertilizers is polluting our environment. Do you think farmers care about these things? If they don't then this is our responsibility to make them think about these things. We have to design a message in such a way that farmers think about these things and also adopt our technique.

This subject of behavioral economics is still an ongoing research and we are doing more research on this subject. In the coming time, we will share the scientific based results of any such findings with you. This is a very interesting area of research where a lot of faculty members and researchers can do research on this and better understand the adoption process of a technique.

Thank you.

Course Name: Conservation Agriculture based Sustainable Intensification
Week 04-Lecture-4: Access to CASI Machineries
Course Instructor: Dr. Ram Datt, Assistant Professor-cum-Jr. Scientist (Extension Education), BAU, Sabour

Hello friends. Whenever we talk about the adoption of conservation agriculture then the availability of machinery and tools on time is very important. This is even more important and true for smallholder farmers. To understand it better, we look at it from a value chain point of view. The most important link in the value chain is the farmer. A farmer needs access to machinery at the required time and he should know how much he has to pay for it. He seeks quality work like if the operator of the machine is not trained then there could be calibration problems in the machine due to which the crop might suffer.

Now, if we talk about eastern gangetic plains, then most of the big farmers here are also service providers. For them, the biggest concern is timely payment of the services they provide. They tell us that farmers get us to work on their farm but then they do not pay us on time. Also conservation agriculture is still not practiced in a large area so the volume of business is small. Another problem that is common is that farms in eastern gangetic plains are mostly fragmented so moving machinery and tractors from one plot to another consumes a lot of fuel which makes it less profitable.

Sometimes, if sowing has already been done in farms that are close to the road, then it becomes difficult to do sowing in plots that are in the inner parts. At times, the service providers also tell us that they require training on how to operate a newly launched machine.

The third stakeholder in the value chain is the government. In Bihar there is a 50% subsidy on machinery that is related to conservation agriculture. But sometimes this process is very complex and people find it difficult to make use of it. The government is trying to make this process easier and now we also have the option of direct benefit transfer. Government is also into capacity development and this is done mainly through research and development organizations. These organizations not just help in capacity development but also develop prototypes and protocols.

Manufacturers also have an important role to play and their main complaint is that the demand for such machines is less. They say this is not a very big business as it is seasonal in nature and many times it becomes difficult to procure good quality parts and materials for these machines.

Now the most important missing component in the entire value chain is the maintenance workshops. There is still a lack of locally available maintenance workshops because the business for such machines is very less as it is seasonal and also these machines maintenance requires trained people who can fix it. The spare parts of these machines are not easily available in Bihar as most of these machines come from Punjab. So they have to order the spare parts from Punjab.

So we have to understand the entire value chain very well and identify and remove all the shortcomings. Only then we can increase the availability of machines and increase the spread of conservation agriculture.

Now we will discuss the solution to these problems. First, if we want to increase the availability of machines then we have to expand the scaling of conservation agriculture. Once the area under conservation agriculture increases then people will start buying machines and its big business will grow.

Secondly, we can open community based custom hiring centers for smallholder farmers who are not able to buy these machines. In Bengal such initiatives have proved to be very helpful to the farmers. We will discuss a related case study in the last week of this course.

Some startups also provide conservation agriculture related machines through custom hiring or through service providers. In Bihar we have such a startup called DeHaat with which my friend Shashank is also involved. So startups can also enter and do business in this area.

To strengthen this entire process, we have to do capacity development at every level and we need trained and skilled human resource for it.

By doing all this, we can improve the access of small and marginal farmers to such machines and expand the adoption of conservation agriculture.

Thank you.