System Design for Sustainability
Prof. Sharmistha Banerjee
Department of Design
Indian Institute of Technology, Guwahati

Week – 10
Lecture - 3
Other Design for Sustainability Tools and Approaches – Agriculture

Hello everyone. So, in our continuing series of discussion on Sustainability Tools and Approaches from different domains, in today's lecture we will be discussing about the Domain Agriculture.

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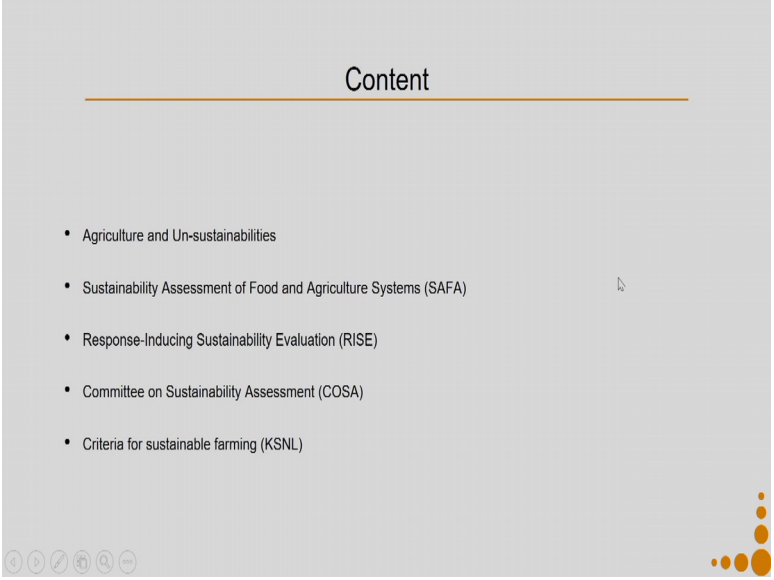

So, what we will be discussing is about some basics related to agriculture, the scenario in the Indian context, the un-sustainabilities related to this particular context. Then, we will go through couple of methods, which are called as Sustainability Assessment of Food and Agriculture System SAFA, Response Inducing Sustainability Evaluation RISE.

Committee On Sustainability Assessment COSA and Criteria for Sustainable Farming. These are some of the guidelines or measurement tools, which can be used in this particular domain for measurement of sustainability or for design of with the sustainability focus. So, let us start with trying to understand in a brief manner about agriculture specially in the context of India.

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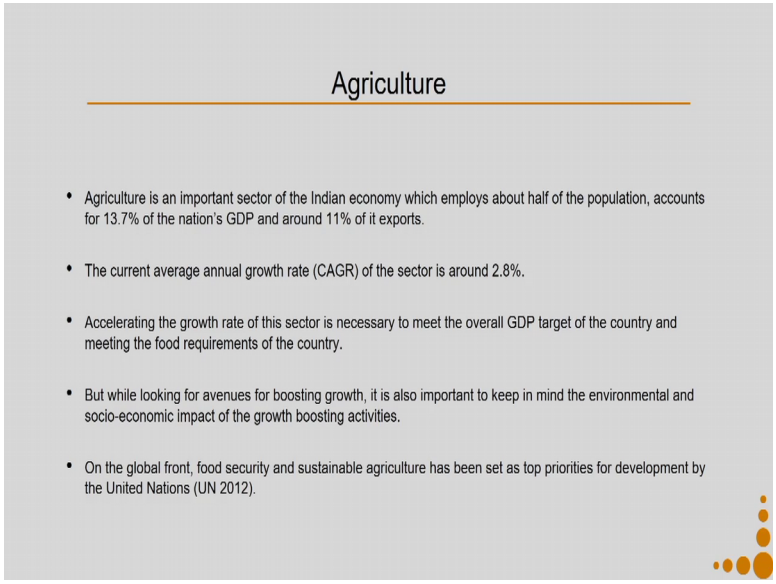

So, agriculture is an important sector of the Indian economy and it implies about half of the populations, and accounts for 13.7 percent of the nation's GDP and around 11 percent of it is exports.

The current average annual growth rate of this sector is around 2.8 percent. Accelerating the growth of this sector is necessary to meet the overall GDP target of the country and meeting the food requirements of the country. Also as you can see it is something which implies about half of our populations. So, you can understand the importance of this particular sector, but while looking for avenues of boosting growth, it is also important to keep in mind the environmental and socio-economic impact of the growth boosting activities.

So, in couple of slides we will start discussing how the current growth boosting activities have had a adverse impact on the environmental as well as the socio economic aspects. On the global front food security and sustainable agriculture has been set as top priorities for development by the United Nations

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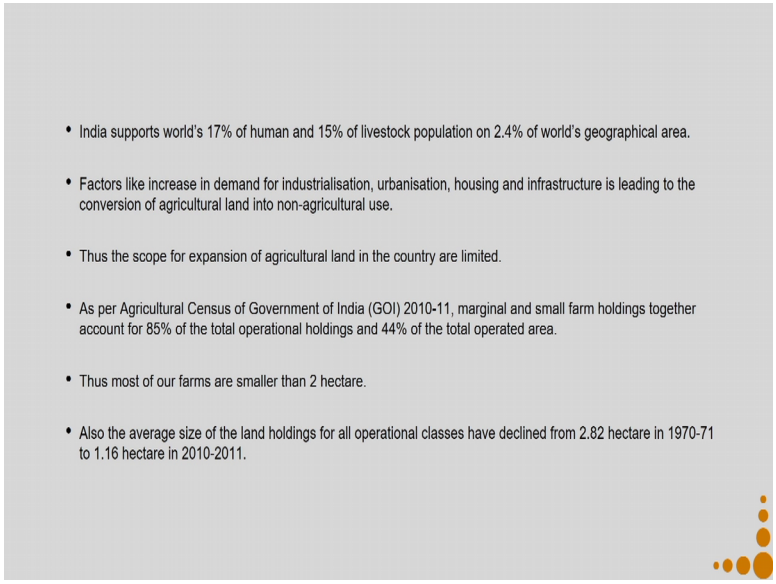

Now, India supports worlds 17 percent of human and 15 percent of livestock population on its 2.4 percent of world's geographical area. Factors like increase in demand for industrialization, urbanization, housing, and infrastructure is leading to the conversion of agriculture land into non-agricultural use. Where does all the new land come from? It comes nowhere from it is agricultural land which is converted into nonagricultural use, which means this land which is available to us for doing agriculture is shrinking day by day.

Thus, this scope for expansion of agricultural land in the country is limited. And, the reverse effect is true that the land is actually decreasing. So, we have to increase a productivity of the land so, that we can meet our ever increasing demand for food. As per agriculture census of government of India 2010-11, marginal and small farm holdings together account for 85 percent of the total operational holdings and 44 percent of the total operated area.

Now, operated area means like not all land which is under agriculture use will be cultivate in each and every year. So, operated area now the operations holdings they marked all those land holdings, which are actually under cultivation. So, if 85 percent of our all farm holders are marginal and small farmers, which means most of our farms are less than 2 hectors in size. Thus, most of our farms are smaller than 2 hectors also the average size of the land holding for all operation classes have declined from 2.82

hectares in 1970-71 to 1.16 hectare in 2010 and 2011. So, you can see the drastic decrease and as the result the requirement to increase the productivity.

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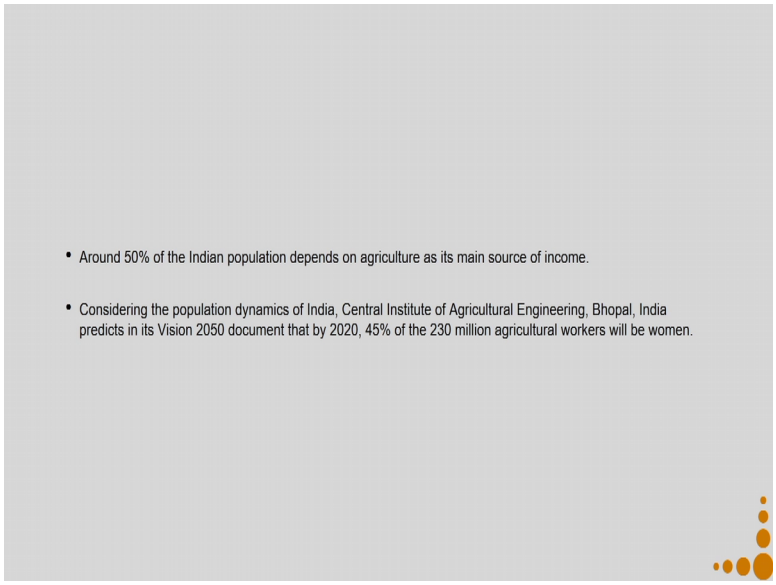

Another phenomenon is around 50 percent of the populations depends on agriculture as its main source of income. Why I am introducing this topic in this particular manner, because a large number of us are not just aware about this entire domain all together. Many of you must be from rural area and agriculture backgrounds and you might know about all these aspects, but mostly people who are living in cities they are hardly ever think about the agricultural domain.

Hence, this kind of an introduction, So considering the population dynamics of India, Central Institute of Agricultural Engineering, Bhopal, predicts in its 2050 vision document, that by 2020 which is just 2 years away 45 percent of the 230 million agriculture workers will be women. So, half of our populations depends on agriculture for its livelihood and of that 45 percent, which means almost half of the agriculture workers will be soon women. And, unfortunately our agriculture machinery development and all those sectors are still not geared up to look into this new demographics, which is emerging in this particular field.

So none of the machine designed keeping in mind the agronomical requirements of the female populations or then requirement that one needs to claim the women to operate them. So, coming to the after this brief introduction I will tell you about some of the

problems. So, two of the main sustainability related issues which usually gets discussed in the domain of agriculture is about food security. So, which means you have to have agriculture, the agriculture had to be sustainable so, that you can ensure food security for the population. And, the other aspect is how can I bring resilience in the agriculture system. So, that it can combat the climate change. So, see for example, farmers who belong historical era. So, farmers usually it learn how to do farming from their forefathers and they have learned it from their forefathers.

So, the existing agricultural practices the cycles, the knowledge have evolved over a long period of time. Now, the climate change that we are experiencing is very drastic with respect to the time frame in which all that knowledge which I developed. So, how in spite of this climate change, how can we quickly adopt our agricultural practices; so, that we can still maintain our the sustainability of our food sources.

So, these are topics related to sustainability in of agriculture, because we need food security and because climate change is impacting agriculture in a big way. Now, let us look at the other set of problems. Problem cause due to agriculture advances in terms of sustainability. So, let us start with discussion on environmental aspects.

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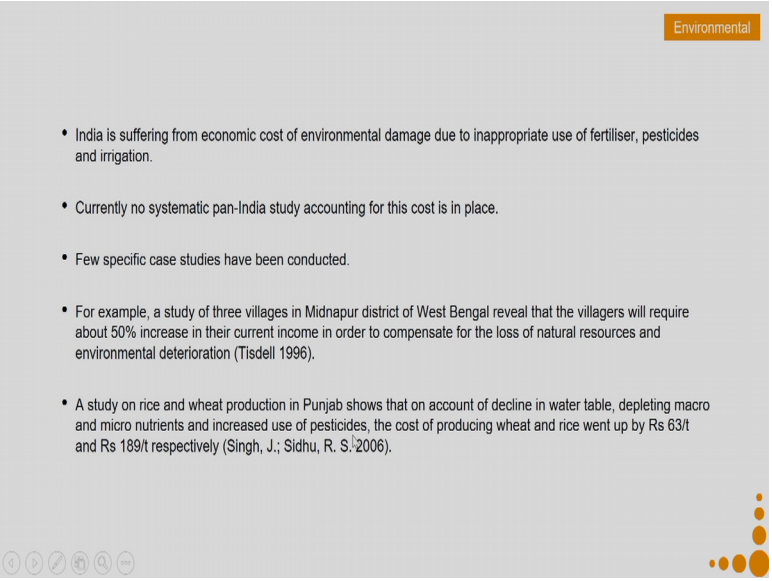

So, India so, all of us know about the green revolution, which started mostly in the northwestern part of the country. So, Punjab, Haryana, Western Uttar Pradesh and adjoining regions, they were the once who adopted green revolution first. As the result

they use of fertilizers, pesticides, irrigation facilities, machinery they saw a boost and all that resulted in a bumper crop production for the country and bringing in food security for us.

But, slowly we can see the economic cost of environmental damage. So, if you remember in our life cycle assessment, we were trying to figure out what is the economic cost of environmental damage. Now, the green revolution has taken place couple of decades back. And, now we can slowly see the economic cost of environmental damage that we have done, due to the inappropriate use of fertilizers, pesticides and irrigation. Although, there is no systemic pan-India study accounting for this cost is in place, but some studies have been done in certain pockets.

So for example, a study of three villages in Midnapur district of West Bengal reveals that the villages will require about 50 percent increase in their current income in order to compensate for the loss of natural resources and environmental deterioration. So, you can see this study has been done way back in 1996 this might have increased quite a big buy today. Why so, because of the environmental damage caused to the soil fertilizers and pesticides have poisoned the soil to a certain extent any one need more and more of them, you have over harvested the fields without living the fields sallow and so on.

So, as a result to the natural resource of soil has suffered degradation; so, in order to still keep on producing the crops so one has to put in lot more fertilizers and other such inputs. So, there is a cost related to these inputs. So, in order to incur those cost the farmers will have to have 50 percent increase in their current income. So, that they can spend that much amount of money also say for example, due to over irrigation, due to taking out of too much of water from the soil in many parts of the country, the water table has gone way below the mark.

So, the amount of energy so, now, you have to have deeper and deeper bore wells to get water. So, the amount of energy spend to draw the water for irrigation is has also the money has tremendously increased. So, a study on rice and wheat product in Punjab, this is a study from 2006 shows this is also a decade back study. So, shows that an account of decline in water table depleting macro and micro nutrients and increased use of pesticides, the cost of producing wheat and rice when up by rupees 63 per ton and rupees 189 per ton respectively.

So, here you can see the point that you were trying to discuss, India is suffering from economic cost of environmental damage due to inappropriate use of fertilizers, pesticides and irrigation. As, the result of which the macro nutrients, micro nutrients, water table has depleted, crop diversity has reduced leading to increased use of pesticides, and all this has an impact on the amount of input cause for producing crops.

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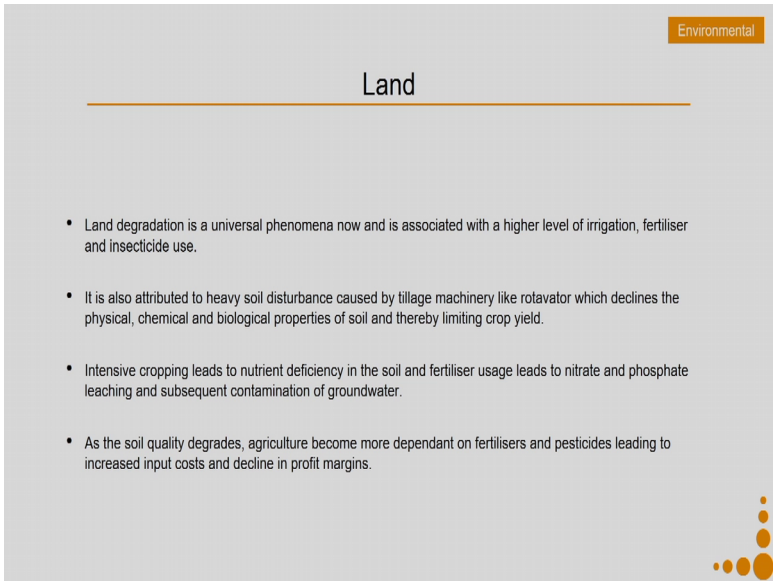

Damages done to the land so, the land degradation is not only an Indian phenomenon, but it is an universal phenomenon now and is associated with higher level of irrigation, fertilizer and insecticide use. It is also attributed to heavy soil disturbance caused by tillage machinery. So, we have used huge machine we like tractor operator, rotavators and all kind of machinery to work on the soil before we can put our crops into it. This has created heavy soil disturbances and decline in physical chemical and biological properties of soil there by limiting crop yield. Also, intensive cropping: intensive cropping means you keep on planting one crop after another without leaving the field with some time to recuperate.

So intensive cropping leads to nutrients deficiency in the soil and the fertilizer uses leads to nitrate and phosphate leaching and subsequent contamination of the ground water. So, when this same ground water is consumed by human beings or the livestock, it again somehow in will end up into our own bodies itself causing health damages. As the soil

quality degrades agriculture becomes more dependent on fertilizers and pesticides leading to increase input cause and decline in profit margins.

So, this is kind of a vicious circle. So, Sikkim has is the first state in India which is declared now completely based on organic farming. So, there is no farm in Sikkim now which uses chemical and chemical fertilizers and insecticides. So, couple of years back the government of Sikkim decided to go completely organic, they removed all subsidies from chemical fertilizers and pesticides.

And, encouraged using say vermi composed which is a kind of a natural fertilizers, and so on, they also trained farmers and how to use these natural bio fertilizers, how to use bio pesticides and so on. And, now the whole state is goes its food organically 65 percent of the organic food, which is in India, comes from the states of Sikkim and you can imagine such a small state.

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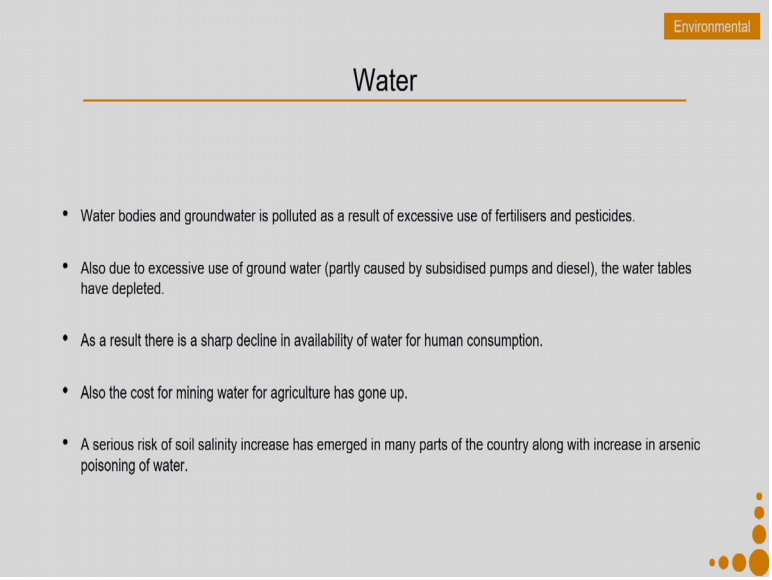

Now, coming to water; so, water bodies and ground water is polluted as a result of excessive use of fertilizers and pesticides. Also due to excessive use of ground water partly caused by subsidized pumps and diesel; so, you can see we created a vicious problem, because you wanted to increase productivity of the land, which was possible when we bring in irrigation facilities. Irrigation can be done by using machines like pumping units and the pumping units needs to run on diesel.

So, the government gives subsidies and pumps and diesels. As, the results many people could afford them now and, but the consequence of that has been a decrease in water table. So now we have to spend more and more money on pumps and diesel. So, your input cost has gone up and at some places a water level had depleted so, badly that even doing agriculture is no longer a viable solution. So, as the result there is a sharp decline in availability of water for human consumption as well.

Also the cost for mining water for agriculture has gone up, a serious risk of soil salinity increase has emerged in many parts of the country along with increase in arsenic poisoning of water. Because, of too much of watering and also because water table have gone down and lead to arsenic poisoning, soil salinity has increased. And in such conditions of course, crops cannot grow because each crop needs optimal soil salinity.

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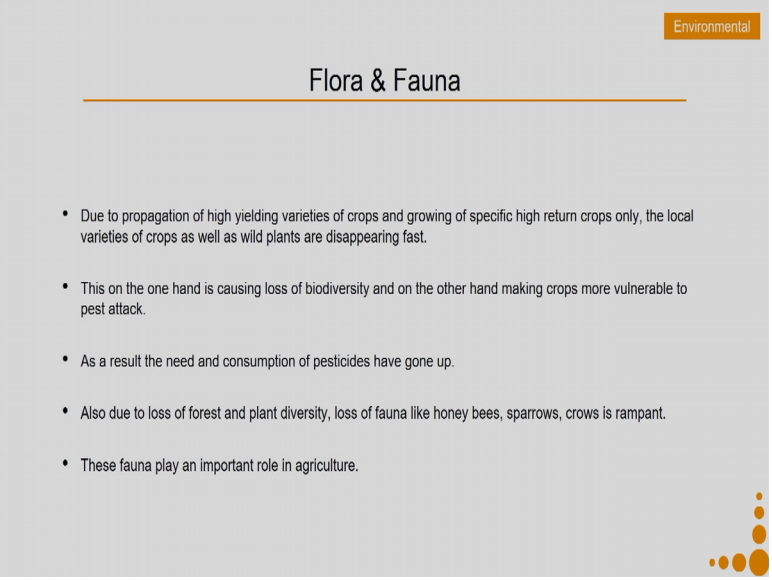

Now, coming to the Flora and Fauna so, due to propagation of high yielding varieties of crops and growing of specific high return crops only, the local varieties of crops as well as wild plants are disappearing fast. So, when there use to be lots of different kind of local varieties of crops, along with wild plants pest attack or disease attack was much lower because of the variety being present.

Also, because the varieties had evolved over time so, they know how to counter act each other the impact of pests and so on, but with the with that option of high yielding varieties. So, hectors after hectors there will be only 1 type of variety or may be 2 types

of variety, which led to increased vulnerability to pest attack and hence requirement for more use of more pesticides.

So, this on the one hand is causing loss of bio diversity and on the other hand making crops more vulnerable to pest attack. As a result the need and consumption of pesticides have gone up. When the need and consumption of pesticides will go up also the input cost of doing agriculture will grow up leading to problem over the farmers. Also due to loss of forest and plant diversity, loss of fauna like honey bees, sparrows, crows is rampant and all of us know they are very very important for our agriculture to survive. These fauna play an important role in agriculture.

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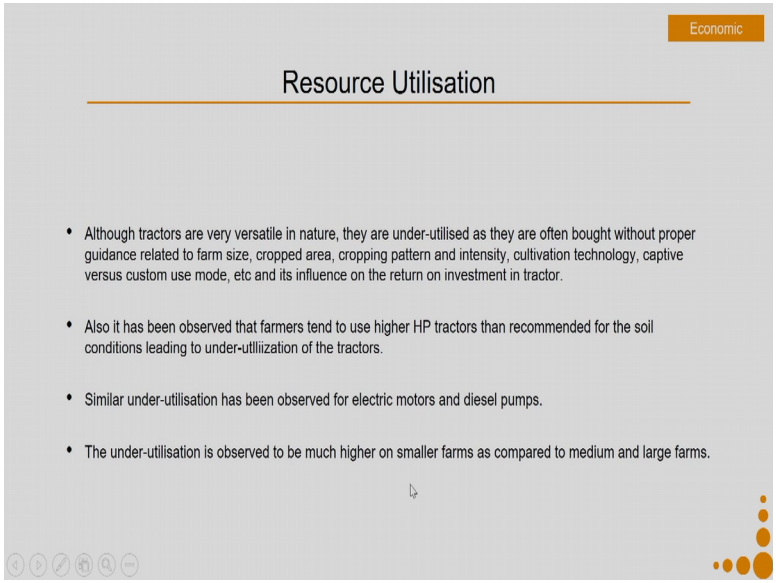

Now, let us discuss about the economic un sustainabilities which have been brought in. So, economic un sustainabilities because of the non optimal resource utilization. Say for example, so, I am not presenting an exhaustive list of them I am just presenting few of them which gives you an idea, that if you are interested to work in this domain where will you look for resource utilization related optimization and un sustainabilities.

Say for example, all the tractors are very versatile in nature they are under-utilized as they are often bought without proper guidance related to farm size cropped area, cropping pattern and intensity cultivation technology, captive verses custom use mode etcetera and its influence on the return on investment in tractor.

So, tractor can be a 120 HP tractor can be 150 HP tractor can be a 200 HP tractor. Now, while you go to buy a tractor the farmer should know that what kind of utilization the farmer is going to do with this particular tractor. What all kind of field operations and what size his or her field is, then when I say captive versus custom use mode. So, there might be also some uses like I put a trailer behind my tractor and use it for carrying goods.

Or maybe I use my tractor for kind of river dredging kind of activities. So, I need to know: what are the different activities which I will be doing with my tractor, what on field and what off field activities. When it comes to on field activities, what is my farm size, what is the kind of crops that I want to grow. Whether I what to offer this tractor for services to other farmers also or not. Once I do all this calculations I should be able to find out what type of tractor should I buy, but mostly such kind of actions is not being done. As the result people tend to buy higher energy, higher horsepower tractors then what is required.

And, then what it happens is they do not get enough return on their investment. So, that is why I am talking about economic un sustainability. Also, it has been observed that farmers tend to use higher HP tractors than recommended for the soil conditions leading to under-utilization of the tractors. Similar under-utilization has been observed for electric motors as well as diesel pumps and across all most of the machine rate.

The, under-utilization is observed to be much higher on smaller farms. As compared to medium and large farms that is another area of trouble, because tractors are not very well suitable for the kind of small forms that we have and people still use those implement because there are not many suitable implements available. So, the under-utilization observed over there is very much more drastic than in the medium and large farms.

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Now, let us discuss about this socio cultural unsustainabilities. The green revolution has brought in food security to the country and helped in increasing agricultural income, which is a very very good aspect, but it has also brought in various ill effects along with it. So we will discuss about ill effects as the unsustainabilities and see how can we of course, we have to begin food security, and we have to increase agricultural income, but how can we bring them in a more sustainable manner? So, a study of socio cultural impact of green evolution in the state of Punjab reveals that the socio-economic fabric of agricultural society has changed remarkably in terms of social relations, cultural, health, and economic values.

So how does has that happened? So, some examples of it the change to commercialize agriculture has had an adverse effect of other rural non farming communities like carpenter, lock and smith, whose livelihood used to depend on making agri-tools, but now agriculture machinery is being produced by larger companies, larger manufacturing units. So, they have lost their livelihood. Some researchers also argue that others other social issues linked to current agricultural practices in Punjab are like huge farmer debts leading to increase in suicide, female foeticide, breakdown of social network, unemployment and meager carrier options leading to drug and alcohol addiction amongst youth.

So many researchers have blamed that these adverse impacts on the social cultural fabrics has also been because of the shift towards commercialized agriculture. Some other studies in the Himalayan belt on the impact of shifting to cash crops. So, cash crops are crops which can be sold in the market and you can get money very easily. So, say for example, coffee is a cash crop, tea is a cash crop. So, shifting to cash crops on traditional subsystems agriculture subsystems, agriculture is when you grow crops for your own family's consumption.

Shows that although the farmers income has grown, but their vulnerability due to climatic and market conditions have increased leading to exploitation, but middlemen of marginal farmers. So, be very careful in this particular segment we are not arguing against the usage of modern machinery or chemicals or going towards commercialized farming that is not the point of argument the point of argument is we need to think in terms of long term sustainability. And, what will be the impact of each and every decision that we take and we have to ensure that we design the whole eco system in a manner that long term sustainability can be achieved.

Due to migration of the population towards urban areas, because it is no longer so, profitable to do agricultural or because the non-agricultural laborers like the lock smith the carpenter and so on they have lost their jobs.

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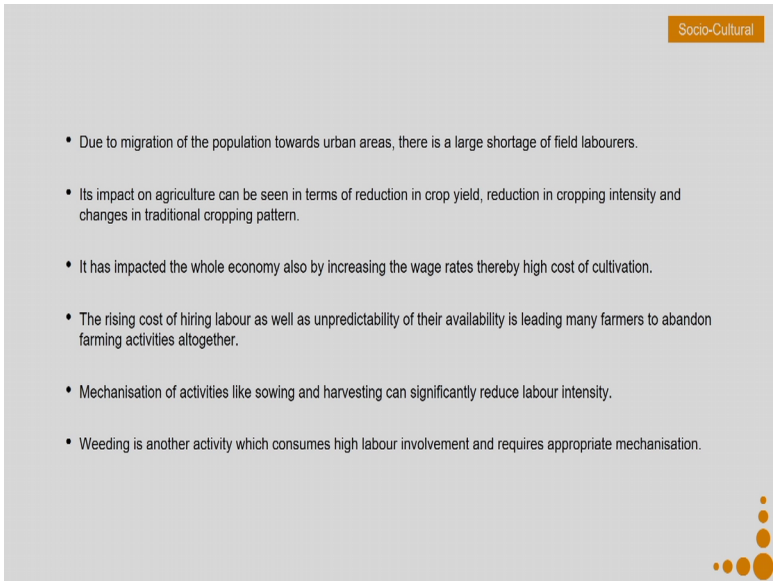

So, there is a migration of populations towards the urban areas. That is leading to last shortage of field labourers and at the same time it is putting a lot of pressure on the urban area. Its impact on agriculture can be seen in terms of reduction in crop yield, reduction in cropping intensity and changes traditional cropping pattern. Why because it field labourers are not available. See for example, still sowing of seeds harvesting of the field is not mechanized to a great extent. Mostly the mechanization complete mechanization has happened in wheat for most other crops this has not happened.

Hence, it is still agriculture is still a labor intensive activity; during the sowing time during the harvesting time. Now because these populations, they have migrated to migrating towards cities again agriculture is no longer viable because the existing laborer is meager and expensive and not available on time. So, everybody needs to harvest their field almost at the same time. Now, there are not enough laborers to do the same.

So, it has impacted the whole economy also by increasing the wage rates there by high cost of cultivation for the farmers. The rising cost of hiring labour as well as unpredictability of their availability is leading many farmers to abundant farming activities all together. So, here you can because all this parameters that do tell us that we may be we if you want to solve this problem, there might be an option that we might do we can go head for appropriate mechanization. Mechanization of activities like sowing and harvesting can significantly reduce labor intensity.

Weeding is another activity which consumes high labor involvement and requires appropriate mechanization. In fact because one has to do weeding so, many times so say for example, some long duration crops like turmeric and ginger, they are long duration crops, they are harvested somewhere between ninth to the eleventh month after they have been sown. So, because of this long duration lots of time weeding has to be done. So weeds all unwanted plants growing in the field. And, the cost of labor cost of weeding is the highest expense for growing ginger and turmeric.

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So, now, let us look at how do we do sustainability assessment in these in the domain of agriculture. So, we will discuss these the 4 tools SAFA, RISE, COSA and KSNL.

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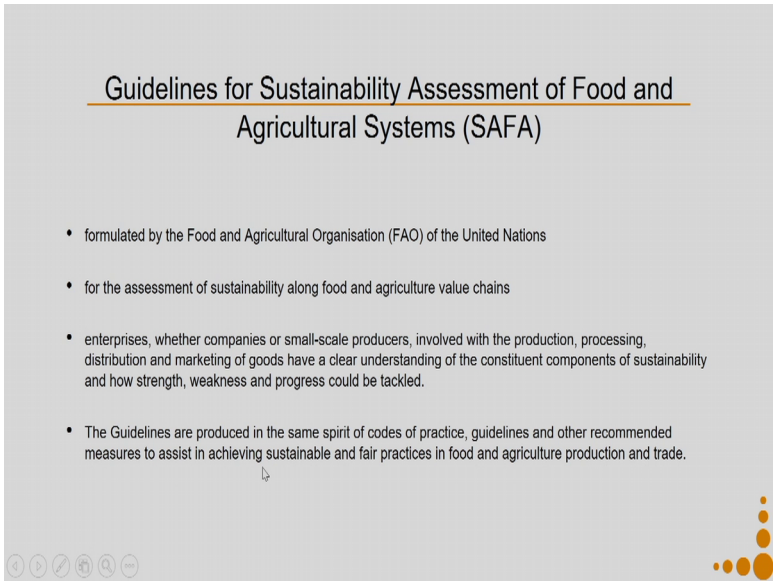

So, the guidelines for Sustainability Assessment Food and Agriculture Systems, this is the very comprehensive guideline. It was formulated by the Food and Agriculture Organization of the United Nations.

It was meant for assessment of sustainability around food and agricultural value chains. It is meant for enterprises, whether companies or small scale producers, see you can see

one of the criteria for using the stool is that it should be an enterprise, which can be either a company or a small scale producer, involved with a production, processing, distribution and marketing of goods have a clear understanding of the constant components of the sustainability and how strength, weaknesses and progresses could be tackled.

The guidelines of produced in the same spirit of codes of practice, guidelines and other recommended measures to assistant achieving sustainable and fear practices and food and agricultural production and trade. So, these are again in line with the kind of guideline that we have been discussing in this particular course.

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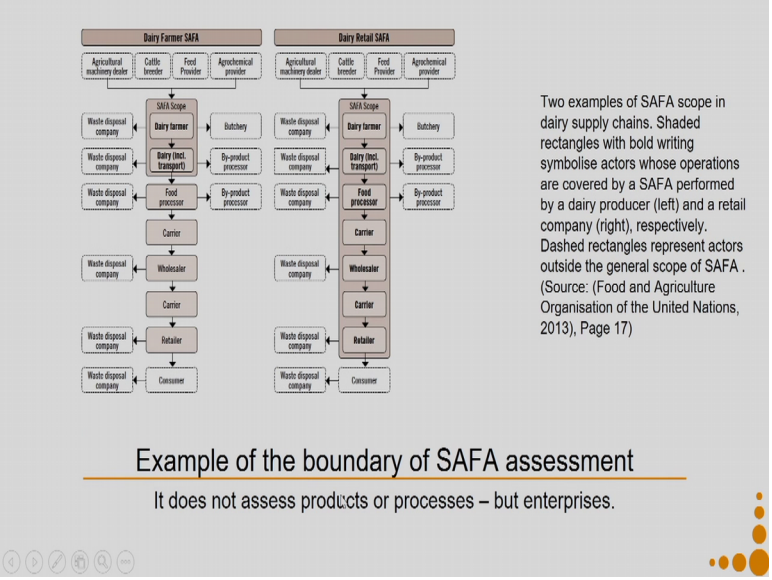

So, this is an example of the boundary of SAFA assessment. So you can see it clearly states that it does not assist products of processes, but it assesses enterprises. So, there are 2 examples over here. The first one is a dairy farmer SAFA and a dairy retail SAFA, a farmer is a producer a retail is a company. So, it can be used for both. So, 2 examples of SAFA scope in dairy supply chains. The shaded rectangles with bold writing symbolized actors whose operations are covered by a SAFA performed by a dairy producer and a retail company, the dashed rectangles represents actors outside the general scope of SAFA.

So here you can see in this particular context. The scope of SAFA is dairy farmer and dairy which is all the processes and the transport included into it, in this particular

context that is the scope of SAFA. Now, agricultural machinery dealer, cattle builder, feed provider, agro provider, all these the waste disposal company or these are also part of this for this dairy farmer to work they have to be part of the system, but SAFA does not do a assessment of these. So, the scope of SAFA is only over here, because we do not assist products or processes what we assess is an enterprise.

So, we will assess the enterprise of the dairy farmer, which consist of the dairy farmer set up inclusive of the transport. Inclusive of the transport because the dairy farmer would not his or her would not transport. And, then again it goes into a different cycle. See for example, if I say the dairy retail, again there are machinery dealers, cattle breeders, feed providers, butchery by product processes and so on, but they are outside the scope of SAFA, they are either products or processes. What is the inside the scope of the retailer is the dairy farmer the dairy inclusive or transport food processor carrier wholesaler carrier and retailer?

So, you can see this was so, here I could have done an individual SAFA for each of them if I want to study the whole system, I can also do a SAFA for this whole thing. So, it has to be a producer or an enterprise. So, does not assess products of processes, but assesses enterprises.

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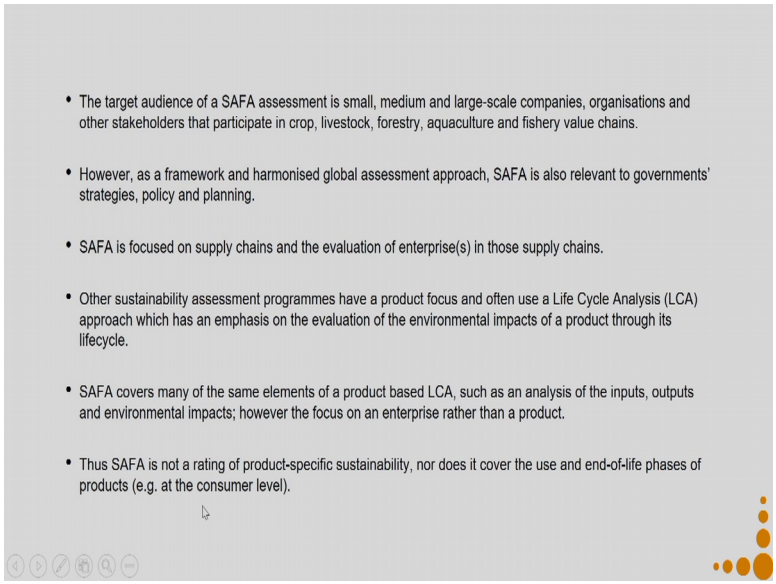

So, the target audience of a SAFA assessment is small medium and large scale companies organizations in other stakeholders that participate in crop, livestock, forestry,

aquaculture and fishery value chains. However, as a framework and harmonized global assessment approach, SAFA is also relevant to government's strategies, policy and planning. It is focused on supply chains and evaluation of enterprises in those supply chains. Other sustainability assessment programs have a product focus and often use a life cycle assessment approach, which has an emphasis on the evaluation of the environmental impacts of the product through it is life cycle

So, it is not that life cycle analysis is not important it is very very important for doing an assessment of the product and the processes, but in the scope of SAFA they are not included they are part of other approaches that can be taken. SAFA is focused on the evaluation of the enterprise. SAFA covers many of the same elements of a product based LCA such as analysis of the inputs outputs and environmental impacts; however, the focus on an enterprise rather than a product. So, the SAFA is not a rating of product-specific sustainability, nor does it cover the use and end of life phases of products, that is that what happens at the consumer level.

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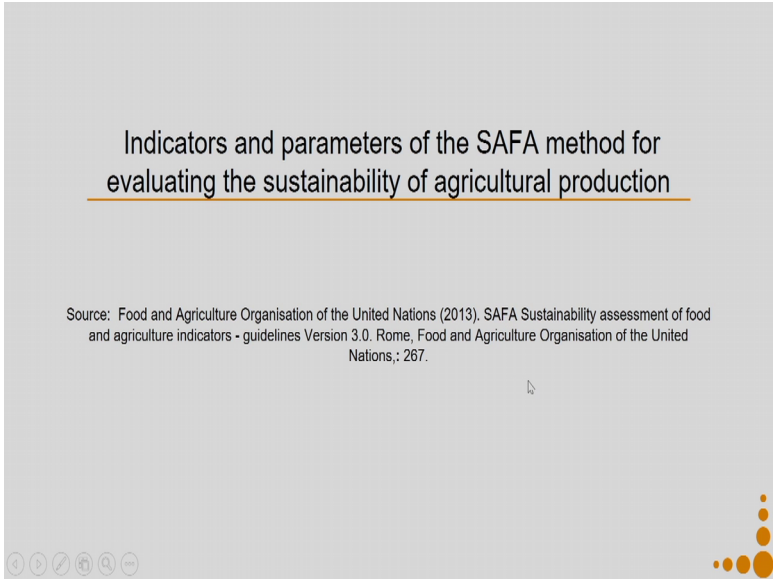

So, there are certain indicators and parameters of the SAFA method for evaluating the sustainability of agricultural production. If, you want to read more about this particular a method, then you can go through this particular reading material.

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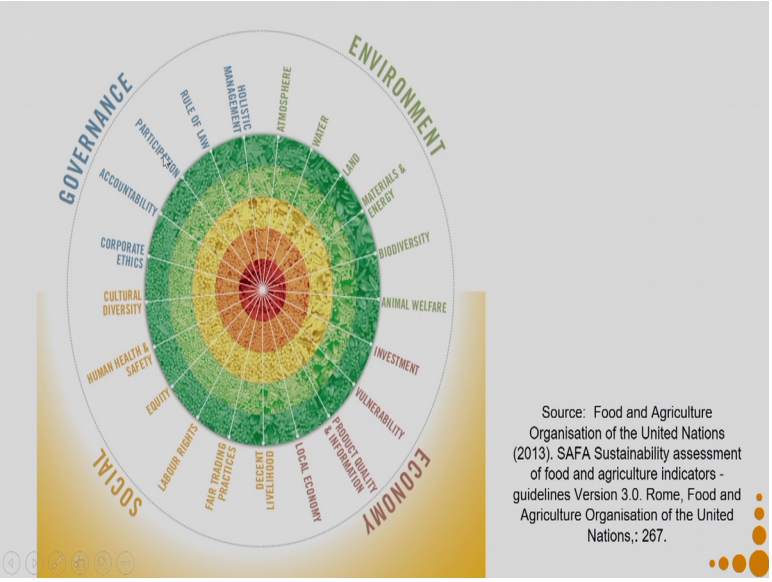

So, to summarize this is how the parameters look like. So, these are called as indicators and parameters. So, I have governance social, economy and environment.

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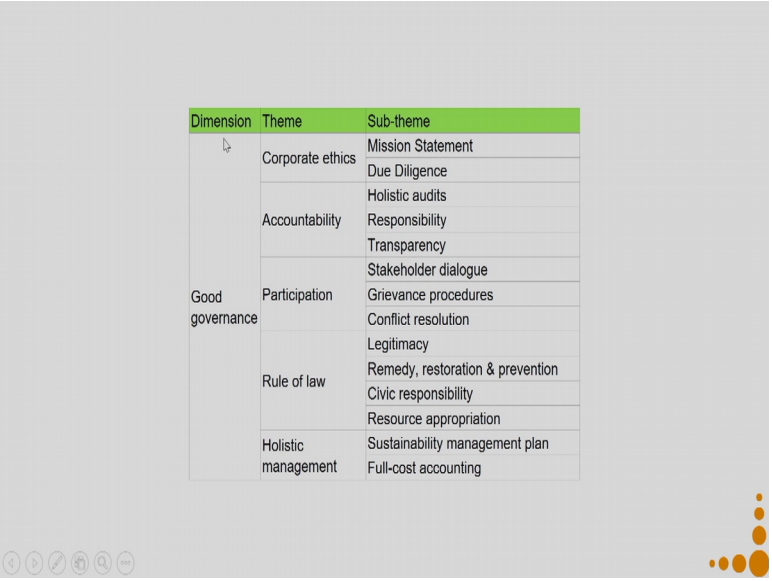

Dimension	Theme	Sub-theme
Good governance	Corporate ethics	Mission Statement
		Due Diligence
	Accountability	Holistic audits
		Responsibility
		Transparency
	Participation	Stakeholder dialogue
		Grievance procedures
		Conflict resolution
	Rule of law	Legitimacy
		Remedy, restoration & prevention
		Civic responsibility
		Resource appropriation
	Holistic management	Sustainability management plan
		Full-cost accounting

So, let us see that dimensions. So, our first dimension is good governance, because I am talking at an enterprise level that is why I am concerned about governance. So, what are the themes inside this dimension corporate ethics, accountability, participation, rule of law, holistic management? There are also sub themes.

So, say for example in corporate ethics we have machine statement, due diligence in accountability holistic audits, responsibility, transparency, when you go through this particular document, you will get to know in detail about more of each of these sub themes and themes dimensions.

The next dimension is about environmental integrating. So, the main themes in this are atmosphere, water, land, bio diversity, materials and energy and animal welfare. These guidelines also they are meant for an enterprise level, you can directly see how the impact is. So, like when you are discussing about unsustainability at the agriculture field, at the end of it the impact is on the farmer on the enterprise. So, you can relate the importance why we need to discuss, whatever we do to the atmosphere is going to ultimately after a point of time haven impact on the enterprise or farming.

. So, atmosphere consisting greenhouse gases air quality, then water land, biodiversity, materials and energy animal Welfare. The next dimension is the third dimension is economic resilience. The themes in it are about investment. So, how internal investment, community investment, long-ranging profitability so, you can if so, all un sustainability that we were discussing in our previous slides. You can put them in one of these sub themes. So, if one would have taken one of these sub themes to begin with and thought on to it we could have come up with alternative solutions, which would have brought in sustainability in this dimension.

Then coming to vulnerability so, stability of productions, stability of supply, stability of market, liquidity risk management, product quality and information so, food safety, food quality, product information impact on the local economy. So, value creation local procurement, then comes the fourth dimension which is social well-being.

So, how can I generate descent livelihood which can be sub themed as quality of life, capacity development, fair access to means of production. fair trading practices, responsible buyers, rights of suppliers, then coming to labor rights, employment relations, forced labor, child labor, freedom of associating and right to bargaining, equity, non-discrimination, gender equality, support to vulnerable people; human safety and health; work place safety and health provisions, public health, cultural diversity, indigenous knowledge, food sovereignty.

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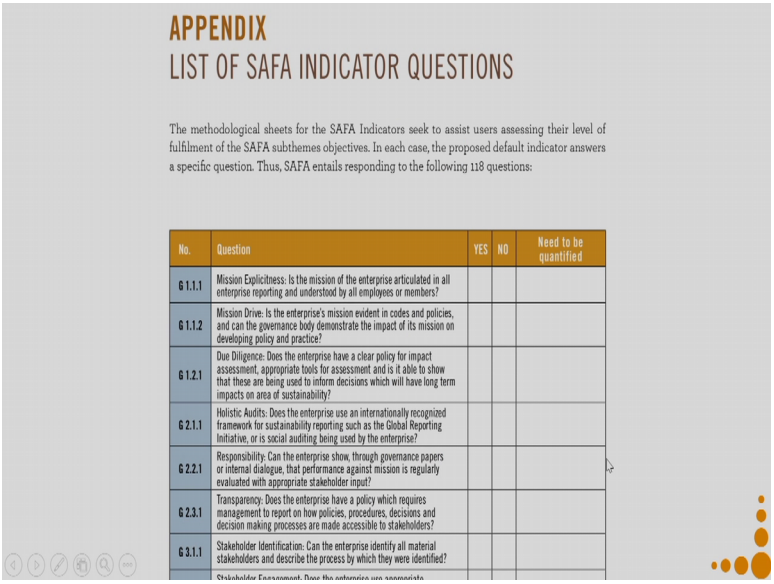

So, now, how do we do this particular, how do we operationalize this particular the method the SAFA? So, the methodological sheet for SAFA indicate a seeks to assist users assessing their level of fulfillment of the SAFA sub theme objectives. In each case the propose default indicator answers a specific question.

Thus SAFA entails responding to the following 100 and 18 questions. So, I have presented only couple of these questions over here as an example, the reading material that I shared that has all these questions the all the 100 and 18 questions. So, a particular farmer a particular enterprise can assist them either by saying yes no and there is an need to be quantified. So, machine explicitness. Is the machine of the enterprise articulated in all enterprises reporting an understood by all employees or members?

So, say if I say yes it is understood then I have to say to what extend? Is the enterprise machine evident in codes and policies, and can the governance body demonstrate the impact of it is vision on developing policy and practice? Say I say no then I might have do certain activities so, that I can come to yes at least to some extent.

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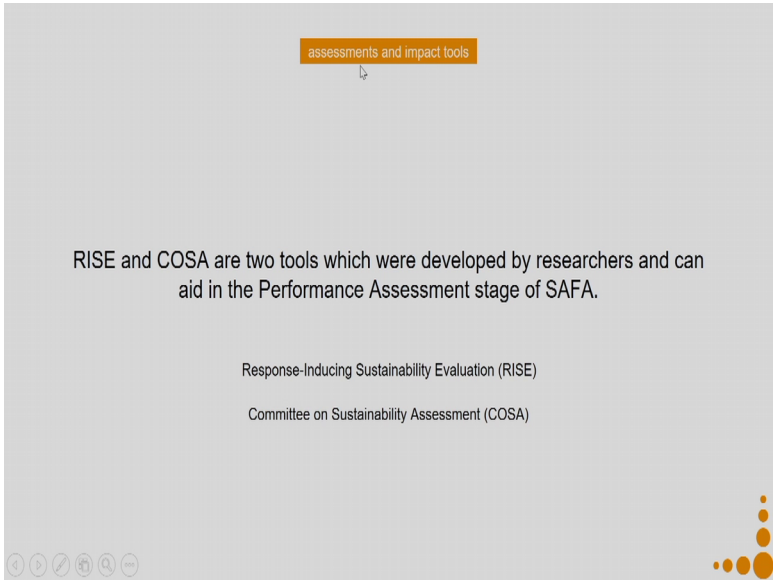

There are more assessment and impact tools. So, RISE and COSA are 2 tools; RISE stands for Response Inducing Sustainability Evaluation and COSA stands for Committee and Sustainability Assessment. So, these are 2 tools which were developed by researchers and can aid in the Performance Assessment stage of SAFA.

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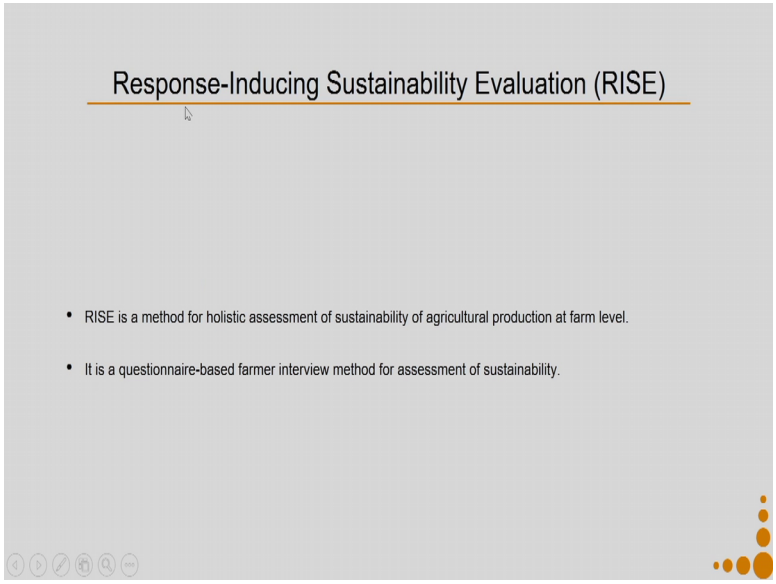

So, Response-Inducing Sustainability Evaluation RISE. RISE is a method for holistic assessment of sustainability of agricultural production at farm level. So, this one only talks about agricultural production at farm level. It is the questionnaire based farmer

interview method for assessment of sustainability. The indicators and parameters of the RISE method for evaluating the sustainability of agricultural production that is what we will discuss; you can read more about this particular technique by going through this particular source.

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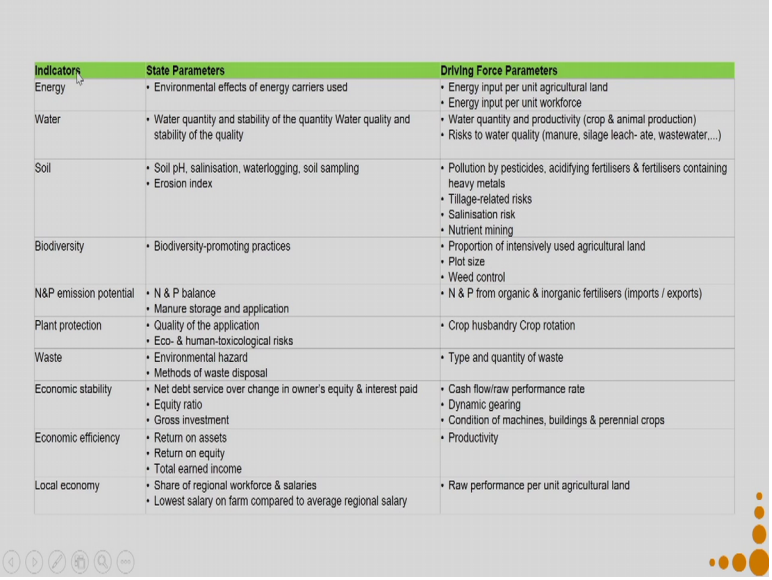

Indicators	State Parameters	Driving Force Parameters
Energy	• Environmental effects of energy carriers used	• Energy input per unit agricultural land • Energy input per unit workforce
Water	• Water quantity and stability of the quantity Water quality and stability of the quality	• Water quantity and productivity (crop & animal production) • Risks to water quality (manure, silage leach- ate, wastewater,...)
Soil	• Soil pH, salinisation, waterlogging, soil sampling • Erosion index	• Pollution by pesticides, acidifying fertilisers & fertilisers containing heavy metals • Tillage-related risks • Salinisation risk • Nutrient mining
Biodiversity	• Biodiversity-promoting practices	• Proportion of intensively used agricultural land • Plot size • Weed control
N&P emission potential	• N & P balance • Manure storage and application	• N & P from organic & inorganic fertilisers (imports / exports)
Plant protection	• Quality of the application • Eco- & human-toxicological risks	• Crop husbandry Crop rotation
Waste	• Environmental hazard • Methods of waste disposal	• Type and quantity of waste
Economic stability	• Net debt service over change in owner's equity & interest paid • Equity ratio • Gross investment	• Cash flow/raw performance rate • Dynamic gearing • Condition of machines, buildings & perennial crops
Economic efficiency	• Return on assets • Return on equity • Total earned income	• Productivity
Local economy	• Share of regional workforce & salaries • Lowest salary on farm compared to average regional salary	• Raw performance per unit agricultural land

So, this particular assessment method it consist of indicators, state parameters and driving force parameters. So, say my first indicator is energy, the state parameter for that is environmental effects of energy carriers used. So, say for example, I am using diesel energy. So, I have to say whatever environmental effects of the energy carrier use. The in that context it is the diesel energy

Say if I am using electricity then for the same say I am using biomass. So, I am burning biomass what is environmental effective effects of the energy carriers used. The driving parameters here will be energy input per unit of agriculture land and energy input per unit work force. Then my next indicator is water the state parameters are water quantity and stability of the quantity of water. So, again the driving forces are water quantity and productivity on the basis of crop and animal production, rest of water quality on manure, silage leach, leaches waste water and so on.

My next indicator is soil so, here again you can see all those parameters on which we are talking about unsustainabilities brought into the agriculture, because of intensive agriculture, you can see all those indicators are present over here. So, we can again take

into this consideration these indicators. These indicators have also been specifically designed for production at the farm level. So, they are very very suitable indicators to be used for doing any kind of design interventions in this particular context. So, I have soil which takes into consideration soil pH, salinization, water logging, soil sampling, erosion index then I have bio diversity. So, bio diversity promoting practices.

I have N and P which is nitrogen and phosphorus emission potential. So, N and P balance manure storage and application. Nitrogen and phosphate emission potential arrives because the use of fertilizers. Then plant protection so, quality of the application eco and human toxicology risks. Because of the plant protection method that we are using say for example, pesticides. They might have some toxicological impact on the ecology as well as the human beings.

Then I have waste. So, environmental hazard methods of waste disposal, economic stability net debt service over change in owners equity and internet paid. Equity ratio gross investment, economic efficiency so, return on assets return on equity total earn income; local economy share of regional work force and salaries lowest salary on farm compared to average regional salary.

So, you can see way I have talking about all stakeholders. It is not only we are talking about the farmer, but we are also concerned about the labors who will be working on that farm we are also concerned about the local economy then we have working conditions.

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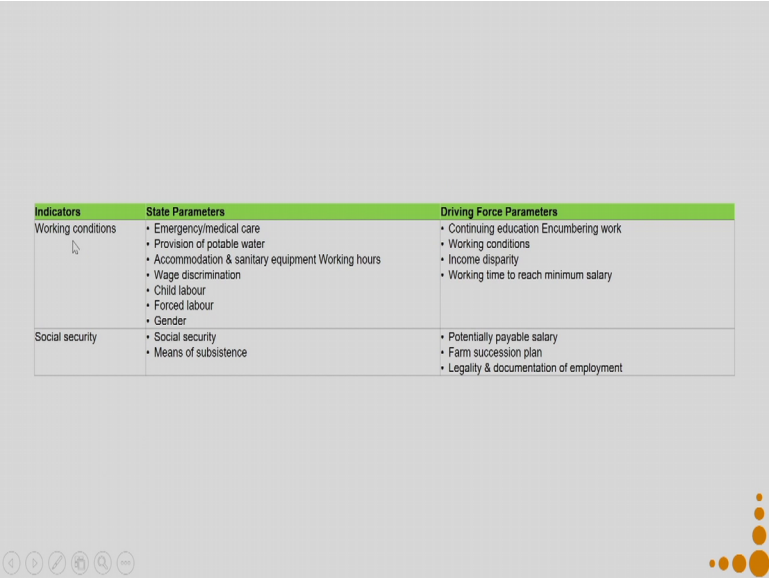

So, emergency or medical care provision of portable water accommodation and sanitation. So, now, you come into the social the socio ethical aspects of it as well. Wage discrimination, child labor, forced labor, gender based discriminations, and the working conditions, then social security.

So social security means of substance. Now, coming to the next one, which is committee on sustainability assessment COSA. So, COSA is a set of indicators used for holistic assessments and monitoring of producer organizations towards sustainability. So, these are organizations of producers. And, it helps in holistic assessment and monitoring of producer organizations towards sustainability. So, it also consist of certain indicators and as you will see these indicators again talk about the same sustainability parameters that we have been discussing so far.

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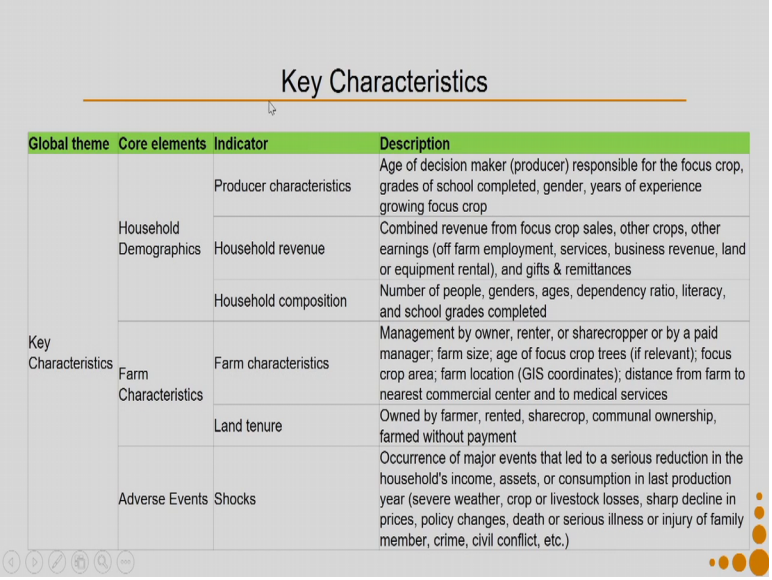

Global theme	Core elements	Indicator	Description
Key Characteristics	Household Demographics	Producer characteristics	Age of decision maker (producer) responsible for the focus crop, grades of school completed, gender, years of experience growing focus crop
		Household revenue	Combined revenue from focus crop sales, other crops, other earnings (off farm employment, services, business revenue, land or equipment rental), and gifts & remittances
		Household composition	Number of people, genders, ages, dependency ratio, literacy, and school grades completed
	Farm Characteristics	Farm characteristics	Management by owner, renter, or sharecropper or by a paid manager; farm size; age of focus crop trees (if relevant); focus crop area; farm location (GIS coordinates); distance from farm to nearest commercial center and to medical services
		Land tenure	Owned by farmer, rented, sharecrop, communal ownership, farmed without payment
	Adverse Events	Shocks	Occurrence of major events that led to a serious reduction in the household's income, assets, or consumption in last production year (severe weather, crop or livestock losses, sharp decline in prices, policy changes, death or serious illness or injury of family member, crime, civil conflict, etc.)

So, in COSA forts it is talks about certain key characteristics. So, they are called as the global theme. So, the key characteristics are it consists of the core element indicators and description. So, the core element in the key characteristics is house hold demographics. So, the producer characteristics; what it means age of decision maker are the producer responsible for the focus crop, grades of school completed, gender, years of experience growing of growing focus crop.

Then I have the house hold revenue; combined revenue for on focus crops sales, other crops, other earnings off farm employment, services, business revenue, land or

equipment rental and gifts and remittances then house hold consumptions. Number of people, genders, ages, dependency ratio, literacy, and school grade completed. So, in first we do a house hold demographics of the producer. To understand the producers characteristics their earnings and their expenditures, then we try to understand the characteristics of the farm, which consists of so, farm characteristics might consist of management by owner, renter, or share cropper or by a paid manager; farm size; age of focus crop trees; if relevant say for example, if it is a mango tree.

So, the mango tree is productive from certain age to till certain age. So, over such context it might be applicable. So, that is why age of crop tree if relevant. Focus crop area, farm location distance from farm to the nearest commercial center and to medical services. So, first we try to understand the farm characteristics to then we try to understand the land tenure. So, whether it is owned by the farm house rented or so on, then I need to understand adverse events what can be adverse events.

So, say for shocks like occurrence of major events that led to a serious reduction in the households income, assets, or consumption in large production year, say for example, severe weather crops on livestock losses sharp decline in prices and so on. Once, I am done with my identification of the key characteristics I will start with my 3 sustainability parameters; the social indicators, the economic indicators, and the environmental indicators. So, let us start with the social indicators.

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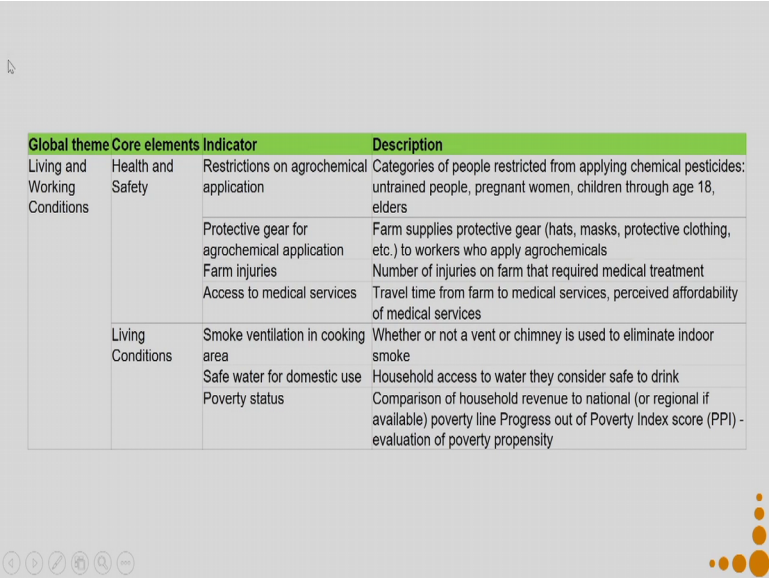

Global theme	Core elements	Indicator	Description
Living and Working Conditions	Health and Safety	Restrictions on agrochemical application	Categories of people restricted from applying chemical pesticides: untrained people, pregnant women, children through age 18, elders
		Protective gear for agrochemical application	Farm supplies protective gear (hats, masks, protective clothing, etc.) to workers who apply agrochemicals
		Farm injuries	Number of injuries on farm that required medical treatment
		Access to medical services	Travel time from farm to medical services, perceived affordability of medical services
	Living Conditions	Smoke ventilation in cooking area	Whether or not a vent or chimney is used to eliminate indoor smoke
		Safe water for domestic use	Household access to water they consider safe to drink
		Poverty status	Comparison of household revenue to national (or regional if available) poverty line Progress out of Poverty Index score (PPI) - evaluation of poverty propensity

Again in when in the social indicators we follow the same patterns we have a global theme, then we have core element, then we have an indicator, and we have a description of the same.

So, the first one is living and working conditions, which consists of health and safety the living conditions, you can again see when I talk about health and safety we are talking about restrictions on agro chemical application protective gear, for agro chemical application, farm injuries, access to medical services, living conditions talks about smoke ventilation in cooking area, safe water for domestic use, poverty status.

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Global theme	Core elements	Indicator	Description
Basic Human Rights and Equity	Labor Rights	Child labor	Time spent by children working on focus crop production
		Minimum wage - laborer	Daily earnings for farm labor compared to (rural) minimum wage
		Safe water for laborers	Laborers' access to water they consider safe to drink during work
	Education	Training	Data include: Training topics and hours attended, fees, time and cost for travel, provider of training
		Children in school at appropriate grade level	Number of household members through age 18 who have completed appropriate number of grades for age
	Food Security	Days without sufficient food	Consistent daily physical and economic access to sufficient, nutritious, satisfying food for all household members; Number of days in past year that any member of household cut food consumption due to lack of food; months of comparatively less food security
	Gender	Women's participation in producer organization	Intensity of women's participation in producer organization indicated by number of ways they participate (attend meetings, vote, serve as delegate, hold executive post)
		Management (by gender)	Proportion of decisions about the focus crop made by women and by men
		Price received Education (by gender)	Price received for focus crop by gender Number of household members through age 18 who have completed appropriate number of grades for age (disaggregated by gender)

My next global theme is basic human rights and equity. Which has a as core element labor right education, food security, gender, many a times a couple of them might not be applicable. See for example, in your region all farming is activities are done by machines. And, hence there is no possibility of employing child labor.

So, in that particular case one of those indicators, because it is not applicable they can be also left, but a majority of them is can is usually applicable. There might be also chances where you might think that certain aspect is not covered into this particular aspect chart and you might also include those indicators into it.

The next global theme is about community we are in the social indicators. So, community is very important. So, in community the core element is participation,

indicated by community services, producer participation in organizations, women's participation in organizations, producer perception of organization's value, then comes trading relationships.

So, whether there is transparency in the trading relationship, whether they have access to market information, price transfer transparency or whether there is a middle man who is exploiting the producer. Capacity and finance so, financial services production and post-harvest services, community services.

Then comes perception, how do they perceive so, in that we have like; social situation so, producers opinion on social issues, community care of the environment, social training, quality of life. Why is community care of the environment very important? See for example, if I am to get a certification for organic farming. It is not only that in my farm I do not use any chemical fertilizer and pesticides, but it has to be also like in particular radius, that is defined by the certifying agencies. So, say for in a radius of 10 kilometers from my farms. Say for example, no one else should be using chemical or fertilizers or pesticides.

So, it is not I alone cannot achieve it. And, hence for most of these activities it is very important that how I have to see community care of the environment, then social training and quality of life. If you take up the example of Amul as a company and if you take up a producer from there and try to do an analysis you will see. So, if you try to do this assessment for say Amul take a producer from Amul and try to do the assessment on these indicators or say we took up the example of Varnapura. So, if you try to an assessment an the this parameter of a producer from Varnapura, you will see a many of these elements have been actually thought of an achieved. As a result greater sustainability has been achieved on both the context. So, let us go head next to the environmental indicators.

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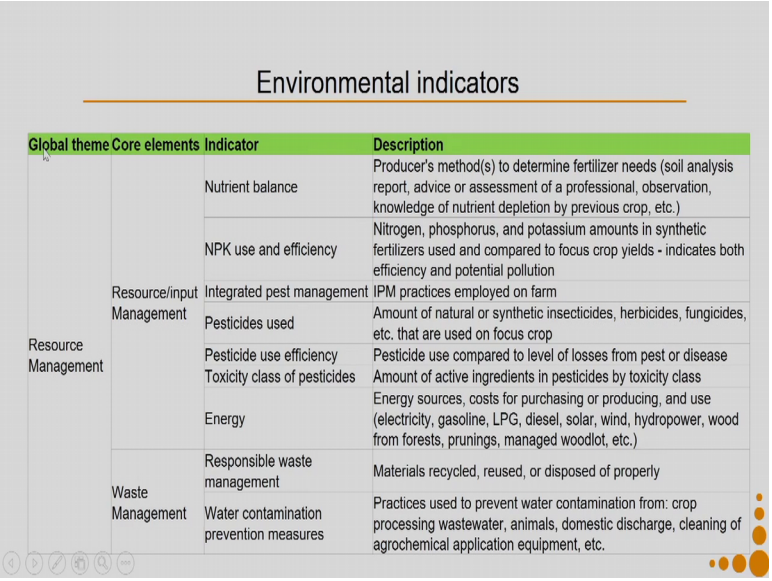

So, the in environmental indicators the first global theme is about resource management. So, here we have resource or input management as the core element were we are talking about so, what are the kinds of resources or inputs? They can be nutrients. So, nutrients can be fertilizers so, producers method to determine fertilizer needs, soil analysis report advice or assessment of a professional, observation knowledge of nutrient depletion, by previous crop etcetera. There are scientific methods available by which a producer can determine the right kind of fertilizer mix, suitable for his or her crops.

So, whether that kind of activity is undertaken before applying the nutrients or not then NPK use efficiency. So, nitrogen, phosphorus, and potassium amounts in synthetic fertilizer used and compare to focus crop yields - indicates both efficiency and potential pollution. Then, I have integrated pest management. So, integrated pest management we can do multiple activities together to do pest management. So, not necessarily pesticide is the only solution for doing pest management, but say for example, you can also alternate 2 crops, which can bring in pest management there can be many other such techniques.

So, whether those techniques are being employed on the farm or not; the pesticides use the amount the type pesticide use efficiency, toxicity class of pesticides, and then the

energy used for doing all these activities. Next in the resource management is how waste management happens at the farm? So responsible waste management is happening or not in which we have to consider material recycled, reused, or disposed of properly. Say for example, if biomass is being generated, say all the leftovers of the after growing rice. So, we took away the rice and what happens to the rest of the plant that is biomass. So, it can be burnt with the waste or biomass as well as it produces polluting effect to the environment. It can also be converted into brigades and used for generating electricity of course, it does generate pollution, but it also generates electricity.

We can also that is also a very good sources of nutrients. So, we can also use that as nutrients and put it back into the soil or we can also use it as a cattle field. So, responsible waste management is happening or not. Then water contamination prevention measures whatever is being taken. So, here we will consider crop processing waste water, animals, domestic discharge, cleaning of agro chemical application equipment etc all kinds of water contamination all kinds of water waste water which is being generated and if water contamination prevention measures are being taken or not.

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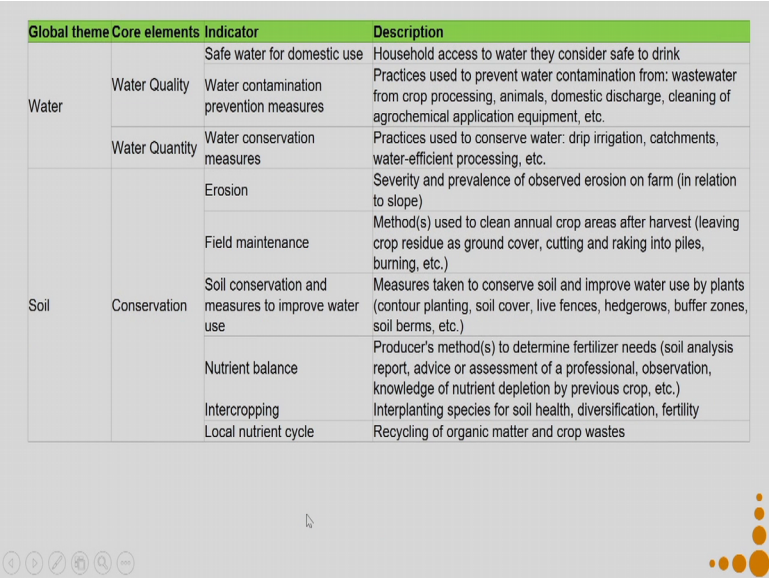

Next global theme is about water, were we talk about water quality and water quantity. So, safe water for domestic use, water contamination prevention measures and water conservation measures. The next global theme is about soil and we are talking about soil conservation. Conservation from erosion, erosion can happen due to water, can happen

also due to winds. So, if there is no vegetation cover on top of the soil, you can have erosion caused by winds. Then field maintenance how it is being maintained so, methods used to clean annual crop areas, after harvest that is whether the crop residue is left on the ground cover, whether they are cut, they raking into piles burning etcetera.

Soil conservation and measures to improve water use so, measures taken to conserve soil and improve water use by plants. So, say for example, like contouring plant or say by making a hill around the plant, or by planting the crop on a raised bed one can do proper soil management, depend different crops they have different requirements. Say for example, rice requires to be dipped in water, whereas say wheat requires to be away from water.

So, appropriate measures which are related to soil conservation and improve water usage. So, nutrient balance how it is achieved? So, nutrient balance in a manner, that it is related to soil conservation. So, we already discussed that if we do not put the fertilizers properly they are going to damage the soil, because of either the phosphorus or the potassium being excess in water or causing arsenic pollution in the soil or increasing the salinity of soil. Then comes inter cropping so, inter cropping is like growing 2 or 3 crops together, in alternate say alternate rows or an alternate columns. This helps in by inter planting we can have better soil health, we can also have diversification, soil fertility improves pest attack also reduces, weed attack also reduces.

Then, local nutrient cycle so, recycling of organic matter and crop ways why local because of the local say land conditions, weather conditions, the nutrient cycle in each region might be different. So, considering them in order to achieve soil conservation; say for example, in hilly areas, soil conservation is to be done in a very different manner as compared to that in the plains.

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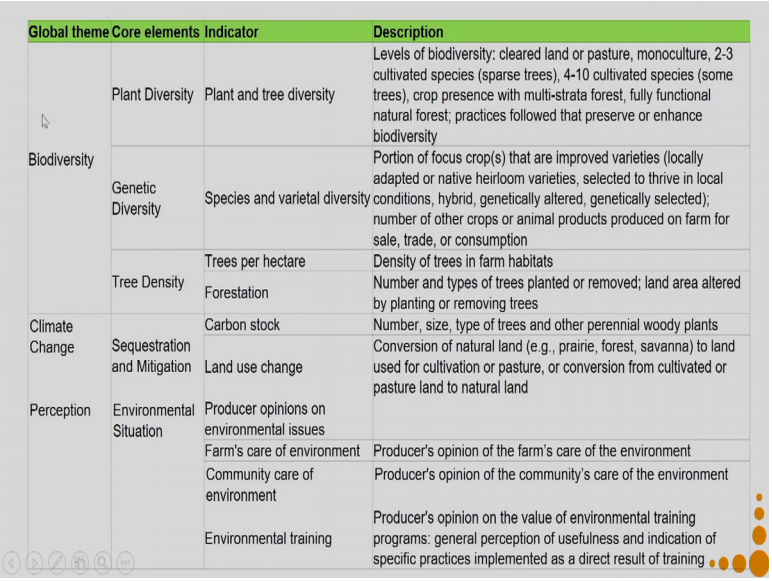

Global theme	Core elements	Indicator	Description
Biodiversity	Plant Diversity	Plant and tree diversity	Levels of biodiversity: cleared land or pasture, monoculture, 2-3 cultivated species (sparse trees), 4-10 cultivated species (some trees), crop presence with multi-strata forest, fully functional natural forest; practices followed that preserve or enhance biodiversity
	Genetic Diversity	Species and varietal diversity	Portion of focus crop(s) that are improved varieties (locally adapted or native heirloom varieties, selected to thrive in local conditions, hybrid, genetically altered, genetically selected); number of other crops or animal products produced on farm for sale, trade, or consumption
	Tree Density	Trees per hectare	Density of trees in farm habitats
		Forestation	Number and types of trees planted or removed; land area altered by planting or removing trees
Climate Change	Sequestration and Mitigation	Carbon stock	Number, size, type of trees and other perennial woody plants
		Land use change	Conversion of natural land (e.g., prairie, forest, savanna) to land used for cultivation or pasture, or conversion from cultivated or pasture land to natural land
Perception	Environmental Situation	Producer opinions on environmental issues	
		Farm's care of environment	Producer's opinion of the farm's care of the environment
		Community care of environment	Producer's opinion of the community's care of the environment
		Environmental training	Producer's opinion on the value of environmental training programs: general perception of usefulness and indication of specific practices implemented as a direct result of training

The next comes is how do we tackle biodiversity, in terms plant diversity, genetic diversity and tree density. So, plant diversity talks about plant and tree diversity, genetic diversity talks about species and varietal diversity available. So, you can always read the description to know more about them so, like portion of focus crop that are improved varieties locally adopted or native heirloom varieties selected to thrive here in local conditions, hybrid, genetically altered, genetically selected and so on.

Then in tree density comes trees in per hectare as well as forestation. Then next one is climate change sequestration and mitigation. So, how do we do carbon stock, how do we use do land use changes to achieve that. Again the last one so, for each of them the last one is about perception, because perception is very important to achieve anything. Hence, it is also important that one should be able to capture the perception of the producer. So, environmental perception later environmental situation, which will be indicated by producers opinion on environmental issues. Farms care of the environment, community care of the environment, and environmental training. Next, we come to the economic indicators.

So, in this the first global theme is about producer livelihoods, which we see the core element is revenue were we are talking about focus crop revenue, yield, price, farm revenue, household revenue. Say for example, the price is not at all in the control of the producer may be, it might be governed by local market conditions, global market

conditions, governmental policies and so on. Again you can see here when we are talking about farm revenue we are also talking about training. So, income from providing services like training, nurseries, land and equipment rent etcetera.

So, all those activities involved together. Then, household revenue, then the next core element is cost. Direct cost for focus crop labor days, labor cost, fertilizer cost, pesticide cost, renovation cost, deductions by buyer, energy cost, indirect cost for focus crops if any so, these can be like capital assets cultivation practices. So, cultivation practices it might be say like drip irrigation, or conservation tillage, or contour planting. So, they are certain cultivation practices which requires certain cost to be incurred. So, say for example, if I do drip irrigation.

So the drip irrigation I set it up once. And it is not like I have to set it up every year I might have to spend some money on the repairing and replacement of components, but I do not have to do every year. So, this is related to cultivation and it is called as an indirect cost because it is not directly link to the crop that I am growing at that point of time. Whereas, the other cost, were more like for that particular crop for that particular time. Traceability and record keeping cost of standard or standard certification in order to get organic certification and any other certification, one has to apply and spend some money to get that planting and reforestation cost, training cost.

Then, the next core parameter is about income. So, net income from focus crop. The next global theme is risk, the economic resilience. So, if whether there is diversification or not revenue from other crops are there or not area used for other crops, or not number of other crops of animal product other revenue not production related, when you do diversification only then you do economic resilience. Information so, access to market information, price transparency, credit access to credit, credit history then vulnerability. So, say for example, poverty status, minimum wage producer, insurance, whether insurance is available or not whether the producer has it or not. Then there might be also certain vulnerabilities, which come in the way of economic resilience.

So, days without sufficient food, gender income differences profit and loss. The next global theme is about competitiveness; the core element here is business development. So, access to market information, prices transparency, farm price to global reference, the economic indicators for COSA are. So, the first global theme is producer livelihoods,

then we talk about the core element revenue, consisting of indicators as crop focus crop revenue yield, price, farm revenue, and household revenue. Then comes so, revenue is point 1 then comes cost, were we are talking about direct cost, labor days, labor cost, fertilizer cost. So, all kinds of input related cost will be part of this particular analysis.

Once, that is done the it will also include certain kind of direct and indirect cost, then we come to the next one which is income from the focus crop as well as other sources. Then comes diversification, diversification we try to identify all other ways of making revenue, than directly from the crop. When we are talking about information let it to market access price transparency which are very important for a producer to know. So, that he or she can achieve economic sustainability. Then access to credit and credit history next we go upon vulnerability about poverty status, minimum wage, producer, insurance and so on.

So, when you see across all these things you can again see in this case we are trying to discuss about risk and vulnerability. Then days without sufficient food, gender income differences, profits and loss, then we come into competitiveness, they also determine the economic sustainability; competitiveness is determined in terms of business development. So, like access to market information.

So, we also had access to market information in one of the other previous other global theme, but we always talk about the indicator with respect to the global theme. So, here in access to market information we will be talking about in terms of business development and competitiveness, whereas in the previous one where we had access to market information it was about risk that is economic resilience. So, we would be talking in that category about access to market information.

Then we get into further aspects of competitiveness say is there a differentiation available. So, is the producer able to produce some kind of differentiation? Differentiation can be like practices for product quality and harvesting and processing or due to product quality or due to some kind of certification or standard which will give this producer a competitive advantage in the market, then we come into efficiency.

So, when we are talking about efficiency we are talking about the crop the production or labor or technical efficiency and as well as the cost or economic efficiency. They also determine competitiveness. The next global theme is producer organizations where we

are talking actually about the governance. So, this producer will be part of certain producer organizations. So, first we try to understand the governance.

So, the sustainability various criteria say like how is the women's participation in the various organizations, is it encouraged, it is discouraged or there are disparities or is it only a women only organizations. There are many producer organizations which are can also say that it is only women oriented organization. Then producer perception of organizations values very important then comes the services. So, like financial services, production and post-harvest related services. Does the producer organization to which this producer is subscribe to provide these services and what kind and in what manner they are provided.

So, like financial services is it on the basis of credit or is it on the basis of some contract or some other some advance or some kind of grant or what is the kind of financial services available. It can be also some kind or insurance related facility, then production and post-harvest services if any say for example, I produce turmeric I need post-harvest processes to process that turmeric into value added products, like dried turmeric or powder turmeric.

So, does the producer organization provide them at a central location. So, all I need to do is procure all my produce to that particular place. Then comes community related services does the producer organization provides certain community services or not, and what kind? These can be related to agriculture so; you can see improvements in agricultural facilities access to water or sewage.

So, either it is related to agricultural facilities or say other things like access to water or sewage, medical care, road or school construction etcetera why we are also talking in the periphery of these services because, firstly, we are talking about community services; secondly, why they are important because this as a whole helps to grow up the producers whole community. As a result everybody prospers not only in the growth of the agricultural products, but an overall growth is possible.

So, if you consider the Varnapura example that we had spoken about in 2 of our lectures. So, you can connect that the Varnapura the Varna cooperative as a producer organization it is involved into many kinds of community services; like they have got into buildings of water reservoirs, can canals, schools, colleges, and so on. Because, overall they improve

the whole infrastructure and as a result the holistic growth is possible, then comes perception. So, economic situation related perception. So, producer's opinion on economic situation, then business development training is available.

So, that was discussion on SAFA, RISE and COSA. Now, we will some other tools. These tools have been are also part of the SAFA tool kit, we will not go into the depth of these tools, but we will see these tools to know of a wide spectrum of tools which are available of these domain. So, this tool is called as Voluntary Sustainable Standards, VSS.

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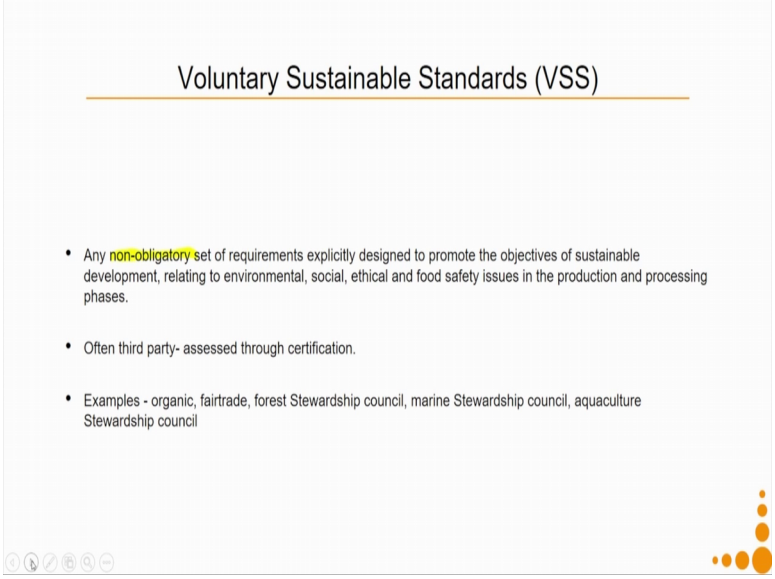

It is any non-obligatory set of requirements explicitly design to promote the objectives of sustainable development, relating to environmental, social, ethical, and food safety issues in the production and processing phases. So, the important point over here it is a non-obligatory set of requirements. It is often a third party access through certification. Say for example, examples in this context are like on organic certification, fair trade related certification, forest stewardship council, marine stewardship council, aqua culture stewardship council. Then comes life cycle assessment tools.

So, these are similar tools the LCA tools that we already discussed there are specifically data sets which has been created for the field of agriculture. So, if say we discussed about open LCA if you go to the open LCA data base, you will see there are certain data bases which have been specifically design with data on agricultural aspects. So,

techniques to access impacts associated with all stages of a products life that is product from inputs, production, processing, manufacture, distribution, retail, consumption, and disposal or recycling. So, life cycle assessment can be done for a particular activity or a particular machinery related to agriculture.

So, examples of this are the eco-invent, as a data base gabi, and is a software or even the open LCA software or SimaPro they will help you to do this life cycle assessment as we had already described. There is also something called as social LCA developed by UNEP SETAC and that can be also used. There is also something called as Sustainability consortium TSC.

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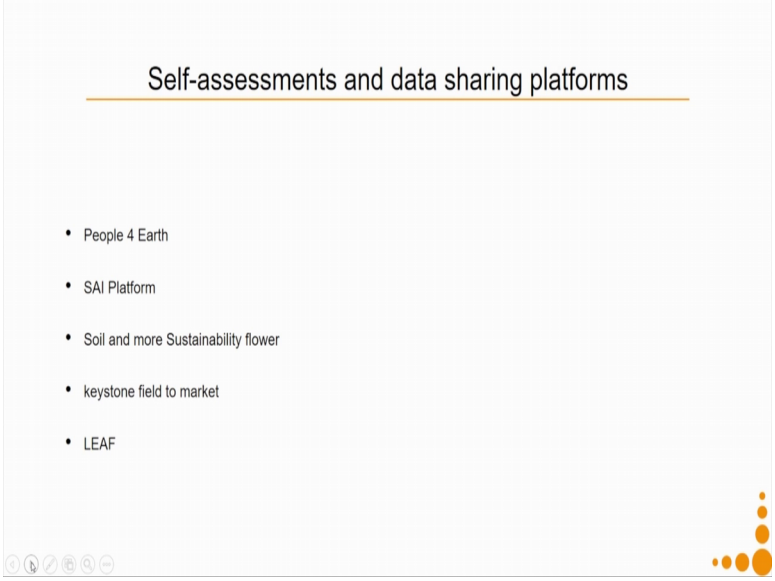

Then there are self-assessment and data sharing platforms available. So, some of these platforms are People 4 Earth, SAI Platforms, Soil and more Sustainability flower, key stone field to market and LEAF. So, these platforms are meant for self-assessment. So, a person who is interested in pursuing sustainability and does not want to go for certification as such what should do a self-assessment; can go ahead share the data and use this data sharing platform. So, now, these and try to do a self-assessment.

In the next lecture, we will be discussing about sustainability and tools, sustainability tools and approaches, which are very suitable for the design of cities and communities.

Thank you.