Introduction to Environmental Economics
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Lecture – 09
Collective Action and Prisoner's Dilemma Game

So, hello everyone, right now we will be discussing the Collective Action problem and the application of Prisoner's Dilemma in understanding this collective action problem.

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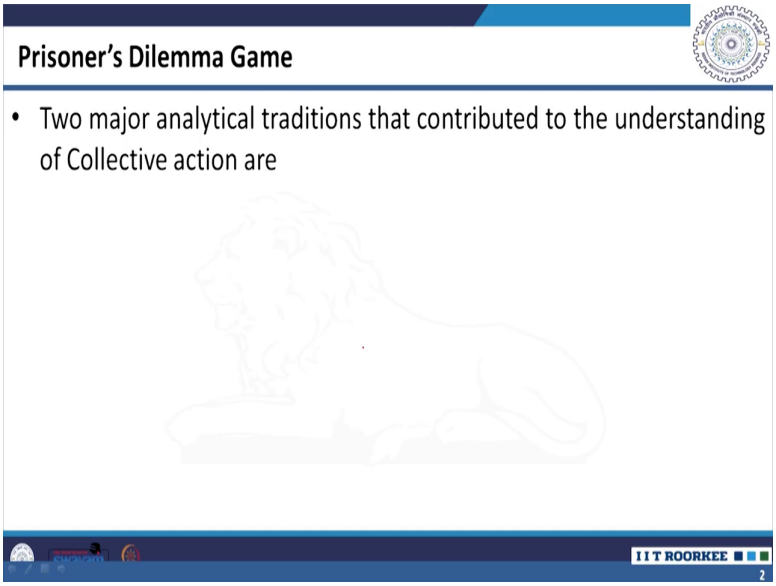

As you have already understood that this collective action problem has been analyzed by taking into account so many theories, starting from hidings to Olson's. So, now we will be discussing how the same problem that is collective action problem can also be explained in terms of this prisoner's dilemma game.

So, before understanding the problem itself let us understand what exactly is the prisoner's dilemma game. So, if you are talking about this collective action problems, then we have already understood the theory of public goods because this theory also helped in describing the kind of the characteristics that the collective goods is possessing.

And it is because of this characteristics this public goods are leading to some issues. So, these are these this ideas which is already had been explained by the theory and developed by Paul Samuelson. And the second one that is also can be helpful or you can say it can be a major analytical traditions and understanding the collective action problem it is by the game theory itself, and this game theory was propounded by Neumann and Morgenstern 1944.

So, although the game theory was originally propounded in 1944 by these two fellow, but prisoners dilemma is actually a very analytical tool which makes us understand the issues of collective actions. And again prisoner's dilemma although it is a part of the game theory, but still it is a it has been developed by Merrill Flood and Melvin Dresher in 1950.

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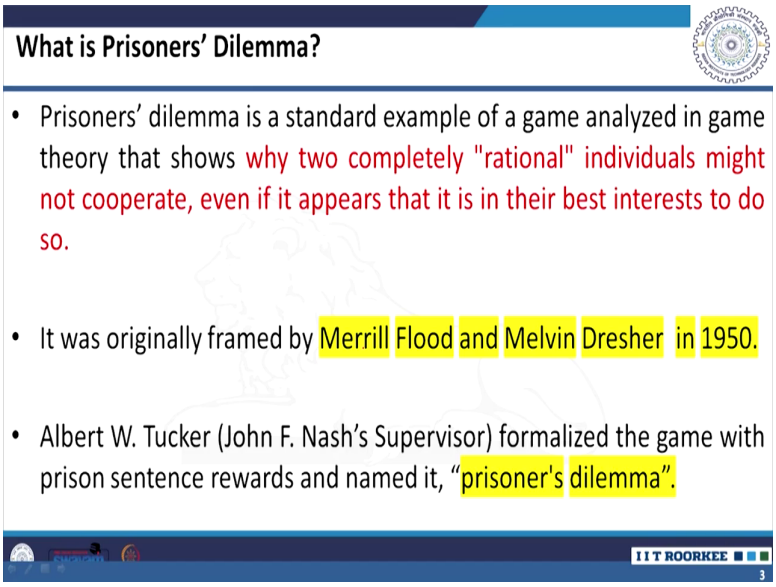

So, what exactly is this prisoner's dilemma? So, you can say that this is a standard example of the game theory that shows why two completely rational people might not cooperate, what is the region behind this? Even if for the third person it is appearing that if they do up cooperate it is in their best interest to do so. But, still the rational individual because they are they are actually following the rationality concept that is why they are not be interested in cooperating, with each other.

And interestingly, why this kind of strategies, or why this kind of phenomenon or game you can say it is known as prisoner's dilemma? Because for the very first time Albert Tucker formalized this game scenario with the example of prisoner's sentence and the reward.

And because of we because the example is explained in terms of prisoners sentence and reward that is why it is known as prisoner's dilemma That is why two prisoners they are not

interested in cooperating although, if they if they are rational in choosing their choices. Although for both of them it is beneficial if they can co-operate each other.

So, in this situation a dilemma it is created which is known as prisoner's dilemma in this example. So, let us understand what exactly is this prisoner's dilemma is by describing the situation itself.

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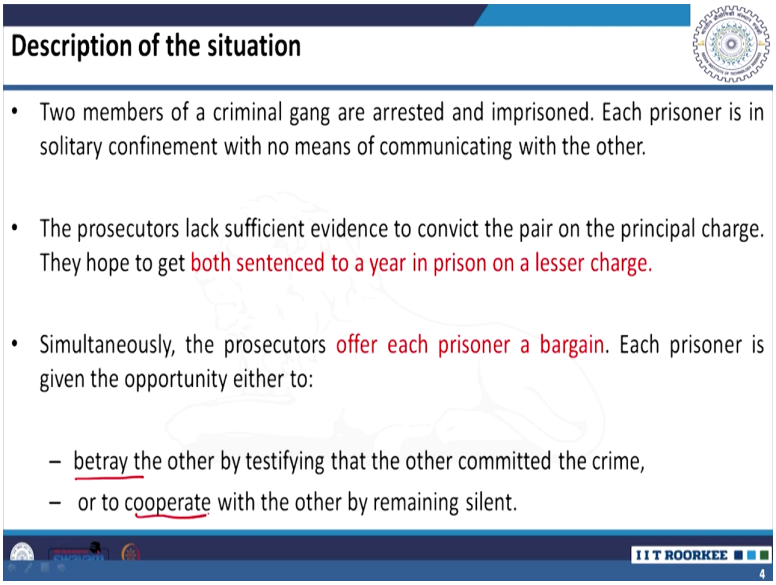

So, here he talked about the situations that two members of a criminal gang they are arrested and that is why they got this they are put in prison and each prisoners is an confinement, he do not have any connections with the other prisoner. So, that he is not he is not able to communicate with each other. So, in these conditions that both of them are isolated and there is no chance for communications.

So, both of them do not know what the other will do whether he will be confusing the crime or not. So, now what happens? The prosecutors because of the sufficient lack of evidence so; they are thinking to convict both of them on the principal charge. And they hope to get this kind of sentences that sentenced to a year in prison on a lesser charge because they prosecutor itself he is not also getting sufficient evidence to convict them.

That is why they are following a lesser charge by putting each of them in the prison by less than 1 year. And simultaneously the prosecutors they are also, they also offer each of the prisoners a bargain. So, each prison is given the opportunity in this cases either betray the other by testifying that the other communicate committed the crime. So, these are the first option, this is the first bargain and the second one is to cooperate with the other by remaining silent. So, what would be now the strategies of these prisoners, either to betray the first option or to cooperate.

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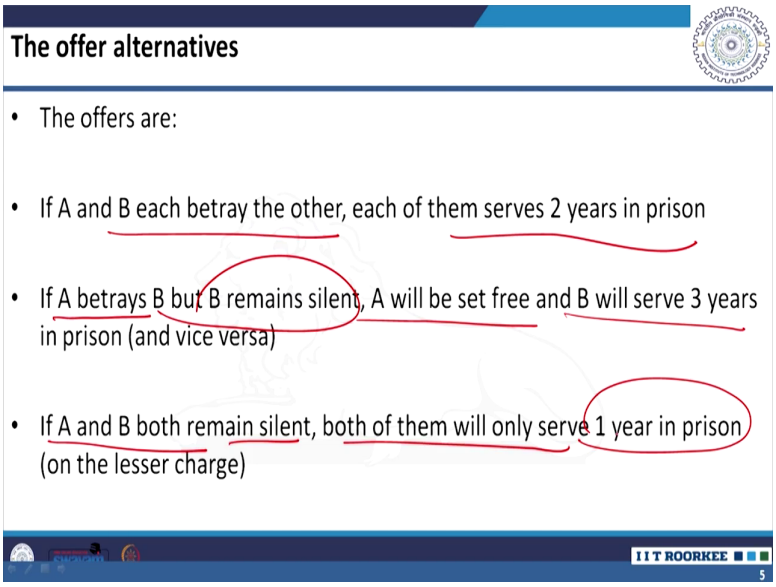

So, given this two offers two alternatives, now the offers would be that if both of these prisoners let us say A and B the each betray each other. Then, they will be getting the sentence for 2 years in prison both are both of them they will be getting 2 years of sentence in the prison. And if in this condition that the first prisoner A betrays, but B remains silent then A will be A will be set free; however, B will be serving the full year sentence that is 3 years in the prison.

And also the vice versa; that means, if a B betrays, but A is remaining silent then B will be set free and A will be serving the term prisoner the prison term for 3 years. And the fourth case is that if both of them A and B they are remaining silent. So, that is a kind of co-operation you are saying co-operating each other. So, both of them will only serve 1 year in prison which is less than 3 years.

So, given this offers these alternatives, now what would be the strategies both of these prisoners will be following. So, this is explained in terms of prisoner's dilemma payoff matrix. So, let us go through that this matrix first, that the strategies both of these prisoners are following that they can be silent they can be betraying each other.

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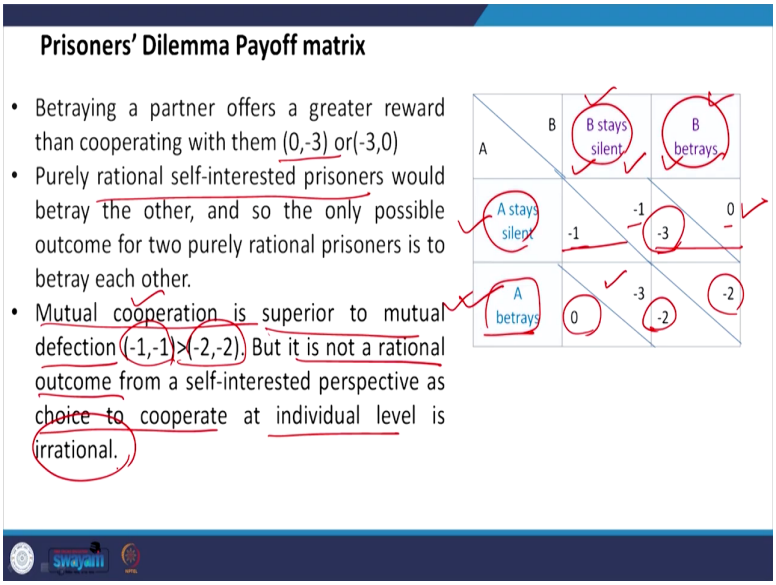

So, let us say that A is remaining silent and B is also remaining silent. So, now the payoff both of them are getting is minus 1 minus 1 that is 1 years in prison. So, both of them will be serving 1 years in prison. Since getting the a sentence in prisoned it is a negative, so that is why it is we are putting negative minus before 1 and 1; 1 year sentence for each. So, now, let us talk about the second strategies that A is remaining silent; however, B is betraying. So, in this can be a context the payoff that will be getting is minus 3 and 0.

So, that means, here we want to say B betrays that is why he is set free he is not he is not going to get any prison term, but A since he is remaining silent he will be punished for 3 years in jail. If you are looking to that the alternatives for A incase A is betraying and B is remaining silent. So, the payoff that we are getting A is betraying means that he will be getting no sentence. So, he will be out of the prison and B is remaining silent. That, means he cannot actually defend whether he has done the crime or not being silent means he has, so its symbolizes that he has committed the crime that is why he is getting the full term of prison that is 3 years, so it is minus 3.

So, if you are looking to the case A is betraying whereas, B is also betraying so that means, Neumann is confessing who has committed this crime. So, the prosecutor will be now be confused that what to do. So, that is why because of the lack of evidence, so both of them will be getting 2, 2 years sentence. So, this is what is explained in terms of a prisoners dilemma case.

So, now let us explain it that betraying a partner obviously offers a greater reward than cooperating with each other. How do you find? If you are betraying a partner; that means, it is betray and betray that is A is betraying and B is also betraying. So, what is the matrix you are finding? It is 0 minus 3 or minus 3 0, right.

And purely rational self interested prisoners they obviously, chose to betray the other. So, the only possible outcome for this two purely rational prisoner is to betray each other because they are rational and obviously, they want to maximize they are own utility by setting themselves free by getting 0 imprisonment year. And in this case if they are following this mutual cooperation. So, in this case in fact this is superior to the mutual defections mutual cooperation means A is also co-operating by remaining silent and B is also cooperating by remaining silent.

So, no one is actually saying the other has committed the crime, so in this case they are actually creating a scenario of cooperation and as a result, the sentence they will be getting is minus 1 minus 1. So, if they are following the mutual cooperation, so this will be the matrix

for them. And if they are following mutual defections, that means A is also betraying it the B and B is also trying to betray A that means, A is blaming B that he has committed the crime and B has also said this the same thing that A has committed the crime.

So, the prosecutor will now be a be confused that who has exactly done the crime and someone must be lying in this case. So, that is why the matrix that we are getting is minus 2 minus 2. So, if we compare the situation then obviously minus 1 minus 1 is greater than minus 2 minus 2 that means, minus 1 minus 1 must be prepared over the minus 2 minus 2; that means, each of them it is likely that both of them should prefer 1 and 1 year in sentence in comparison to 2 and 2 years sentence in this case.

So, if they are mutually cooperate each other their sentence duration can be decreased to 1 year and 1 year each and if they are actually mutually defecting right. So, it is a kind of case of not cooperating each other then this sentence duration will be increased to 2 year and 2 year for each of them. But since this is not a rational outcome for each of this self interested individuals or prisoners because if the prisoners follow the rationality principle, then there should be trying to set them self I mean himself free not taking the others into account.

So, that is why they cannot; this situation of mutual cooperation is not a rational outcome for a self interested prisoner and both of these prisoners are claimed to be self interested. So, in this case it is not at all a rational outcome from a self interested perspective as choice to cooperate at individual level each irrational.

So, here both of them they are realizing that are the individual level following the principle of rationality if they are going to cooperate then it is not at all rational choice. So, this is what we are drawing a kind of dilemma that whether the mutual co-operation although it appears to be superior to mutual defection, but why both of this prisoners here are not cooperating.

So, in this case as we understood from the game theory strategies then you are finding that this defection is the dominant strategies and the payoffs are 0 minus 3 and minus 3, 0 for both the prisoners A and B.

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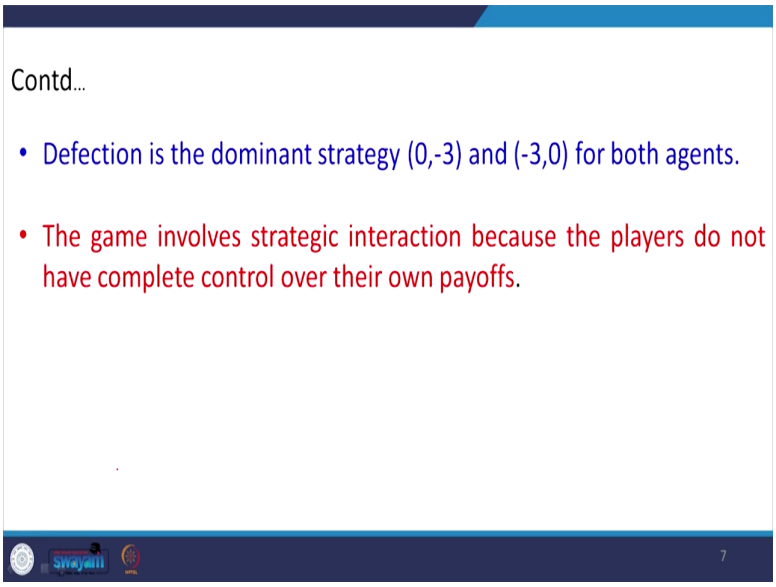

And here the game involves these strategic interactions because the players do not have complete control over their own payoffs.

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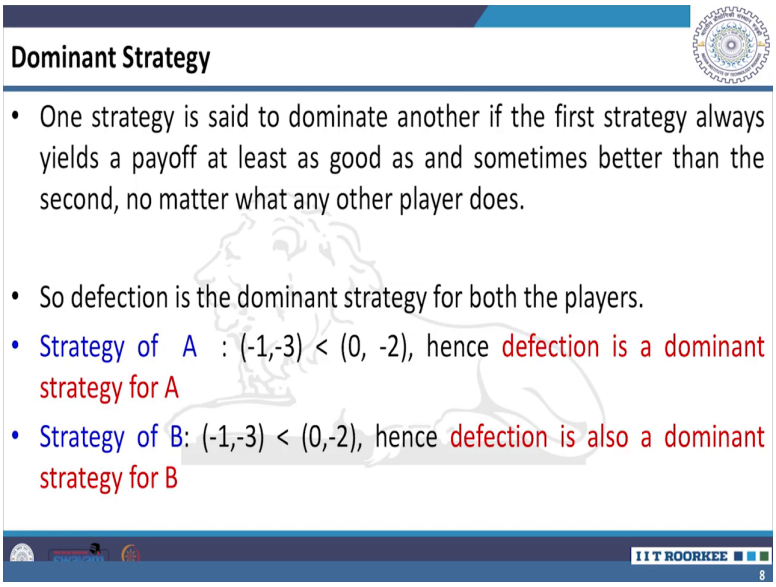

So, what exactly is the dominant strategies because you are saying that 0 minus 3 minus 3, 0. if the dominant strategies for both of them, then what is the meaning of dominant strategies or how you define dominant strategies here? So, in this context the dominant strategies can be defined as the strategies which dominate another if the first strategies always yields a payoff at least as good as and sometimes even better than the second option, no matter what any other player does.

So, when we were saying that it is minus 3, 0 and 0 minus 3 that the dominant strategies then you can find out that these strategies dominate the options for the second irrespective of what the second person is doing. So, in this context the defection is the dominant strategies for both of these players because they are getting the highest payoff for them.

So, if you are comparing the strategies of A that is as far this dilemma a prisoner's box we are finding minus 3 sorry minus 1 minus 3. And here we are finding that this minus 1 minus 3 is obviously, less than 0 minus 2 right. So, in this context defection is a dominant strategies for A.

So, whether this 1 year sentence and 3 year sentence is preferable or 0 year sentence no sentence that means, and 2 year sentences is preferable? Obviously, 0 years sentence that is no year sentence and 2 year sentence is preferable over the 1 year and 3 year sentence. That is why for A defection is a dominant strategies that obviously, he will be preferring to defect now to cooperate. And so for this strategies of B is concerned we can take the payoffs. So, what you are finding? We are finding minus 1 minus 3 and 0 minus 2 in this case then also by analyzing the same thing in the same manner then will be finding that this defection is also a dominant strategies for B also.

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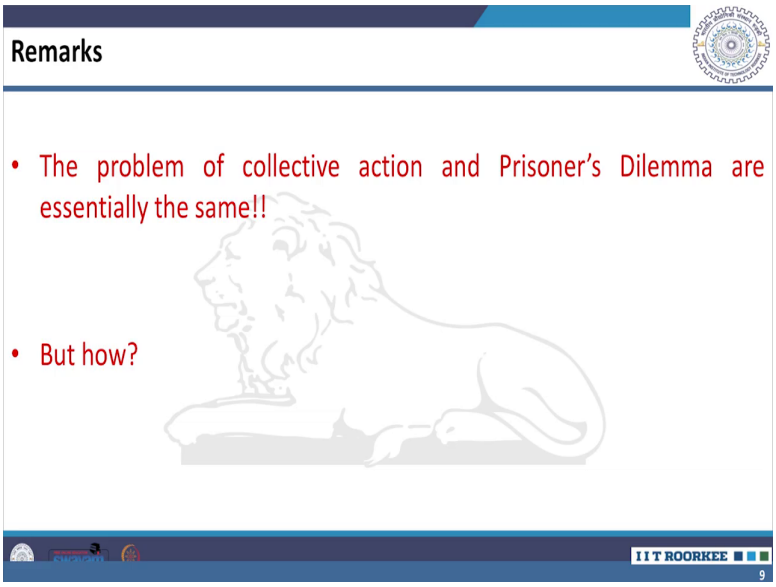

So, in this case as you understand that defection is the dominant strategies, so both of them will be following. So, what is the conclusion we are drawing from this common prisoner's dilemma and how it can be related to or how it can help in explaining the a collective action problem?

So, if you understand what is the collective action problem and what kind of conclusion we are drawing from the prisoner's dilemma, then we can conclude that the problem of collective action is thus is just the same that we are finding the problem of the prisoner's dilemma, they are essentially same.

But the question is that how these two problems are same? How we can say that the problem of collective actions it is just equivalent to or it is similar to the problem of prisoner's dilemma that we have described in this scenario? So, let us talk about this collective actions and we

have already understood from the theory of Olson's Theory of Logic of Collective Actions they are we talked about the concept of latent groups.

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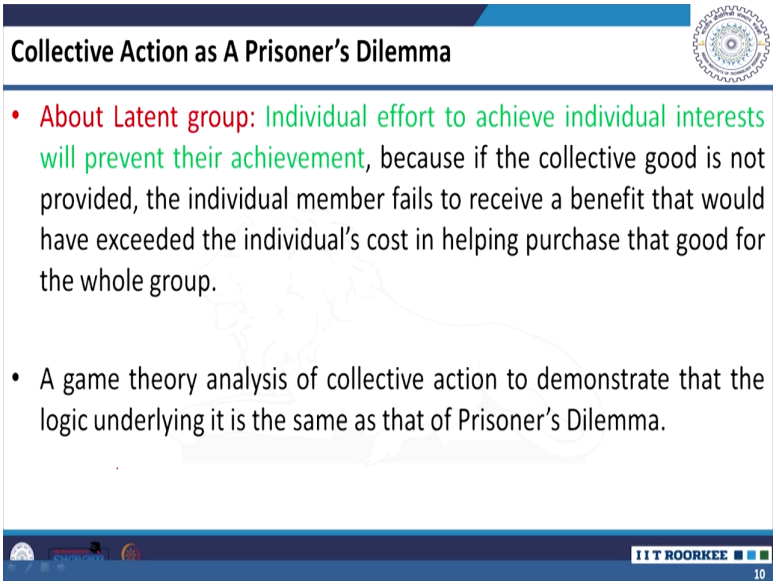

So, if you are analyzing the latent groups, then here individual effort to achieve the individual interest will prevent their achievement because if the collective good is not provided. Then individual member fails to receive a benefit that would have exceeded the individual cost in helping purchase that good for the whole group.

So, in this context what we have actually understood that individual effort to achieve this the particular individual interest will actually prevent their achievement their group achievement. Because, in case of this in this individual effort they are following the principle of rationality and they may achieve the individual interest right. But, because they are rational that is why they will not preferred to.

I think the group object is because the once the group objectives are achieved the benefit of this group objectives will be shared by all the members. So, there is no point that individual member will now effort for achieving the group objectives taking the cost and benefits into consideration. So, this the individual members they follow the principles of rationality. And similarly if you are saying the taking into account the game theory and its analysis.

So, what we are finding? A game theory analysis of collective action to demonstrate the very logic, its just the same as the prisoners dilemma. So, in this case if you are looking to then in case of prisoner's dilemma if both these prisoners they are going to cooperate, then; obviously, their benefits their group benefits will be more in comparison to their individual benefits. But they are not going to co-operate because they are following the principle that we need to be more rational.

So, if you are following this rational principle then it is better to follow that we need to go sentence free. Instead of going to co-operate and finding one your sentence for each of them. So that is why their preference is not to cooperate rather than to defect, although co-operation biggest the highest priority. So, similarly in case of this provision of collective goods in the latent groups if the individuals they would follow.

Thus, the same irrationality that we need to achieve the group objectives then the provision of the group objectives the provision of the collective goods for the group objectives can easily be met. But, deliberately the individuals they do not want to achieve these objectives thinking of that what would happen to their own self interested interest if they are not going to be irrational for themselves. So, by doing so you are actually finding the similar situations that they could have actually co-operate by following their own individual interest for fulfilling the group interest, but they do not care.

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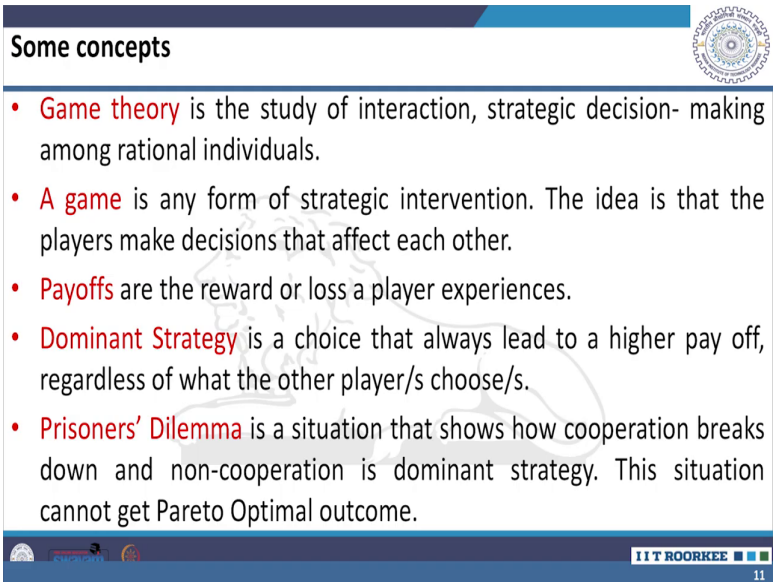

So, in this context a game theory and collective actions as we are dealing with game theory here we need to understand some of the major concepts that we are using here. So, first of what is a what is game theory? So, this is a study of interactions or you can say strategic decision making or strategy set up strategies and which one is to be picked among the rational individual here. So, the assumption is that the players are the are following the rational principles and what exactly is the game, so; obviously, it is a kind of strategies or this strategic intervention for decision making.

And the idea is that or the very underlying assumption is that each of this player whatever the decision they make it can affect the other player. So, that is what they are playing or they are doing a kind of strategic in intervention in the decision making in both of their decisions in fact. And what exactly is the payoff? This payoff are the are in terms of loss or reward in this

example that we have taken into account, it may be a reward in terms of listening the sentence, or a loss in terms of increasing the sentence in the prison.

And what is it that the dominate strategy? So it is a choice that always lead to a higher payoff, regardless of what the other player is choosing. So, in this case the dominant strategy is not to cooperate and not to cooperate for both of the prisoners yielding them the highest the preferred choice.

And what exactly this prisoner's dilemma so it is a situation that shows how cooperation breaks down and now non-cooperation is a dominant strategies. So, in prisoner's dilemma the situation is horizon where it is unlikely to go for co-operating each other rather than preferring the non co-operations.

So, this although this situation cannot get this Pareto optimal outcome, but still the because the players they are following the dominant strategies that is why it is leading to the situations of the prisoner's dilemma. And what exactly is the collective action dilemma here?

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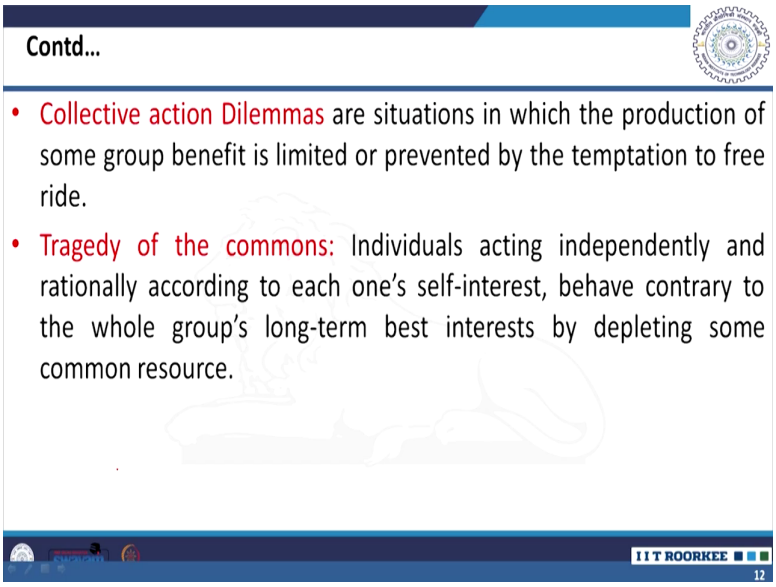

So, these are again the situations and contexts in which the production of some groups their benefit it is limited or even prevented by temptation to free ride. So, in an nutshell you can say that collective action problem is nothing, but the situation which is giving rise to free riding case.

That means, the individual members they will not contribute anything rather than to think that why we need to pay anything we need to actually be accommodated with others expenditure and get the benefit out of it. And another thing in this collective action problem that we have already discuss in discussed in Hardin's theory that is the tragedy of commons again it is a situation.

And in this context individuals act independently and very rationally of course, for achieving self interest which maybe contrary to the group interest. And that is why it results in depleting

some of the common pulled resources, or common resources. So, that is what its already narrated by Garrett Hardin in his tragedy of the common.

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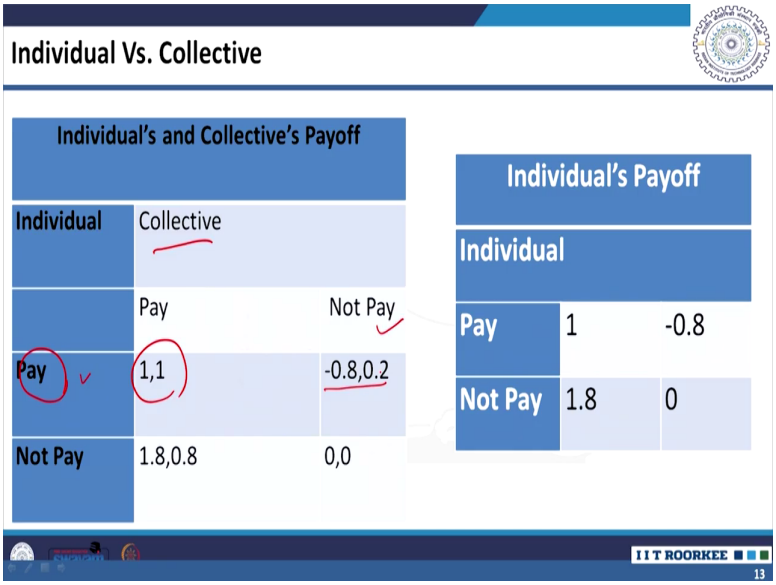

So, now let us I have to understanding the game concepts game theory concepts and the collective action concepts let us have been look into the individual versus collective in terms of the game theory. So, now let us have these that we are taking the payoffs of the collective or group as well as; well as the payoffs of the individual member. How what will be their strategies? Whether they need to pay they will be going for payment they will be likely to they will be liking to pay or not to pay. So, what the individual is concern and so, what the collective a group is concerned.

So, here we can say that this is the pay off. So, in this case for of the provision of the collective actions here the if individual things to pay and the group also things to pay then your

payoff would be 1, 1. If the individual is thinking to pay and the group is not paying anything, then the payoffs is minus 0.8 and 0.8 and likewise. So, before understanding this payoffs matrix let us understand what is the example we are we are drawing this payoffs.

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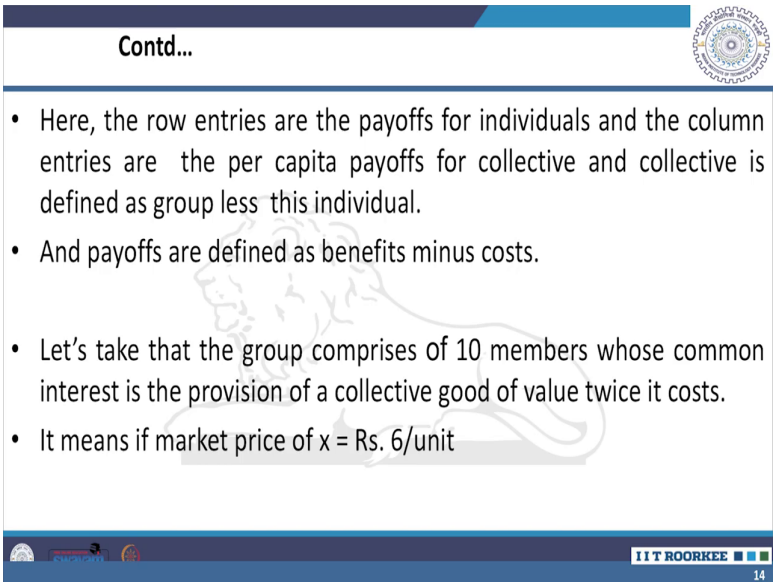

So, here the row entries whatever you are finding the payoffs for the individuals and the column entries they are per capita payoffs for collective. And here collective is defined as the group minus this particular individual which is plain. And payoffs are defined as the minus sorry the benefits that the member is getting minus the cost he is incurring for this collective good.

So, now let us narrate the situations, the scenario is that let us say the group is comprising of 10 members and here the target is the provision of a collective good the collective good of

value twice it costs that means, its actual costs so actual benefit after the provision of this good will be twice that a particular member is spending.

So, it means you can say if the collective good is x is taken as x, then it means the market price of this collective good x lets say is 6 rupees per unit. Then, the members will be paying 6 rupees to enjoy two units of that particular good.

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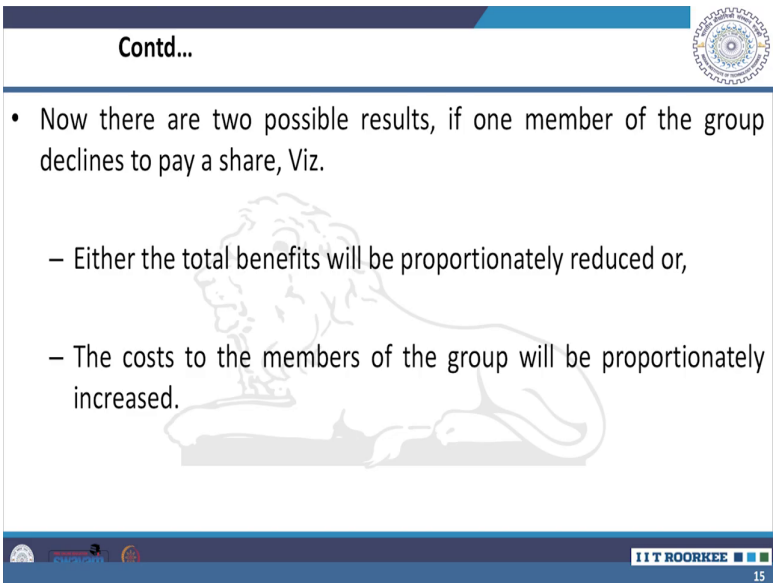

So, this is what the each of the members they would be paying. So, now in this contest so there are two possible results, if one member of the group declines to pay a share, then what will happen? Because sometimes we are also facing this situation and largely in this group behavior the members they want to free ride.

So, if in a case in a group a member declines to pay its own share, then what will happen, what is the possible scenarios? So, either the total benefits will be proportionately be reduced or the second one could be the cost to each of the members of the group now will be increased proportionately because one is not paying.

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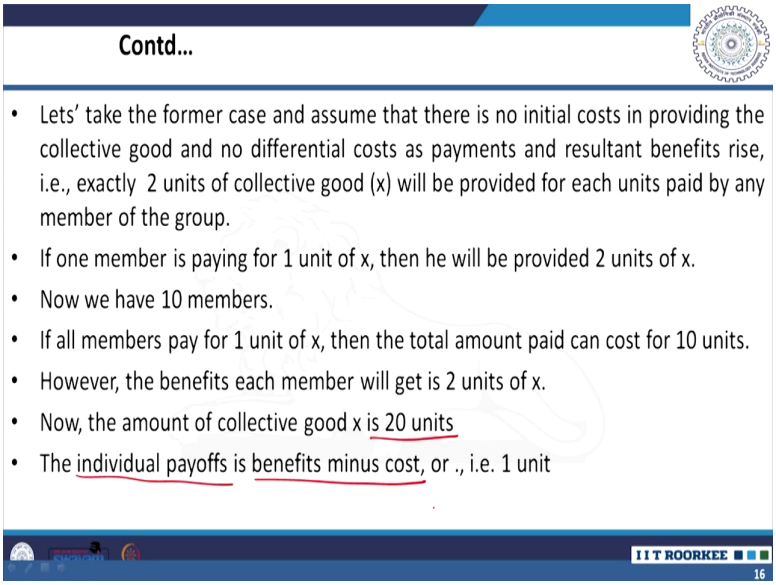

So, if you are taking the former case here right and we are assuming that there is no initial costs in providing the collective good and there is also no deferential cost as payments and the result and benefits it will be giving rise too. So, in this context we are actually talking about this exactly 2 units of collective goods that is x, which will be provided for each units paid by the individual members in the group.

So, if the individual member is paying 6 rupees, then they must be getting 2 units of the collective good itself that is x. So, now as you understand that in this group we are having 10

members. So, if all the members pay for 1 unit for this collective good, then the total amount that would be paid for the 10 units itself. And the benefits each member will get is 2 units of x although the cost they are paying is for 1 unit. So, now the amount of collective good is 20 units because they are paying for 10 units and they will be getting double of the value. So, that is why they will be getting 20 units of the collective good.

So, the individual payoff in this situation can be defined as benefits minus costs. So, what is benefits minus costs? That means, an individual member is paying for 1 unit of the collective good however, he is getting 2 units of collective goods in return. So, that is why if you are if you want to define individual payoff then it will be the total benefits minus cost that is 2 units minus 1 unit is 1 unit here.

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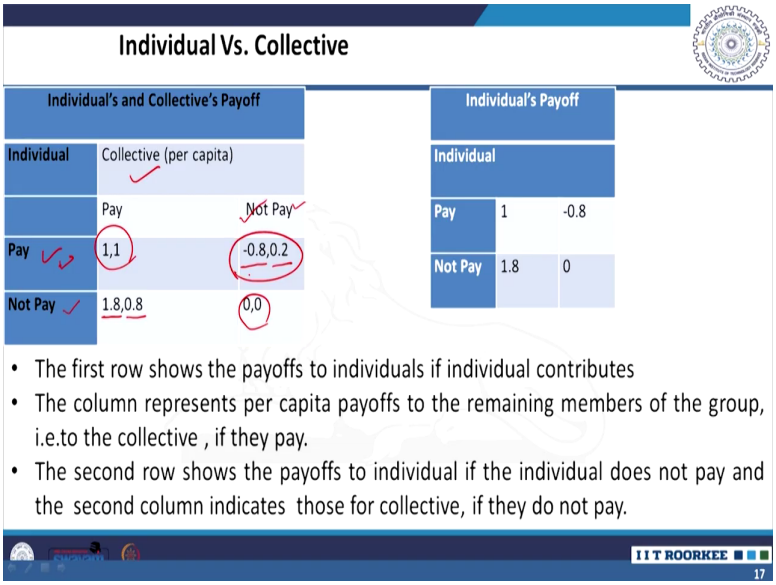

So, now we can understand this payoff table that is individual versus the collective. So, if you can write it out write it down then you will be finding that if the individual is paying. And then and the collective they will be also paying, then the payoff would be 1, 1 individual will be getting the benefit of one collective good and the group is also going to get the benefit of one collective good.

If both of them are paying individual is paying as a member and the collective all the members they are paying that is why collective is paying, so it is 1, 1. So, now let us think because the free riding is an essential characteristics of this collective issue or a collective action. So, if a particular individual is not willing to pay then what will happen?

So, if the individual will not pay then out of 10 members 1 member is not going to pay. How many how many members are paying? It is exactly 9 members who are paying. So, 9 members paying means for how many units of collective goods? It is twice 9 into 2 is 18. So, 18 now the benefit is 18 and its not and this 18 needs to be shared by all the members in the group that is 10 members.

So, payoff for share would be 18 divided by 10, that is 1.8. So, if the individual is not paying, he is getting a share of 1.8. What will be the pay off for the collective? It will be 0. 8 because if all the members are paying it will be 1. But, now one member is not paying that means, 1 minus 0.2 is 0. 8; so this is 0. 8.

So, now let us discuss if the collective is not paying only the individual is paying, what will be happening? So, the collective is paying sorry individual is paying and the collective is not paying, what will be the payoff? It will be?

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Obviously negative. Why? Only one individual is paying and others are not paying, but the benefit is going to be shared. So, that is why it will be once it will be shared the payoffs are going to be decreased and it will be minus 0. 8 and minus 2. And if the individual is not

paying, and a collective is not paying then; obviously, there is no question of providing the provision of the collective good itself.

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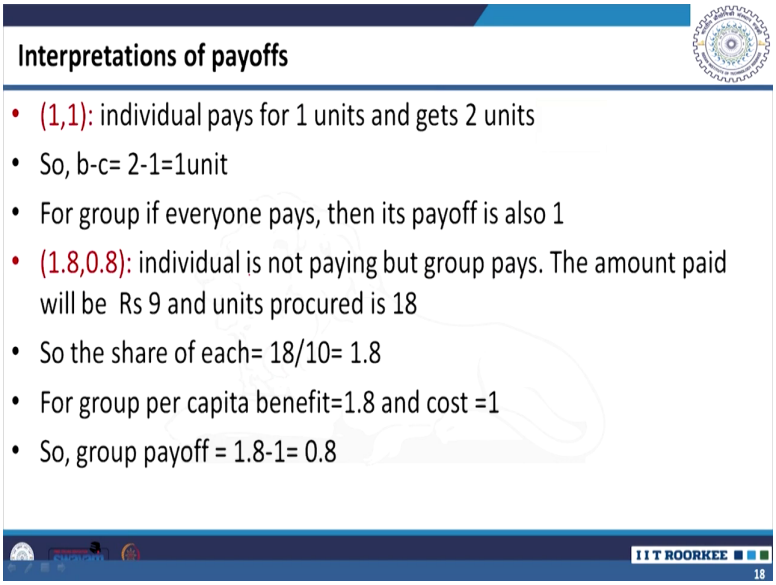

So, now let us actually think about this minus 8 and minus 2.

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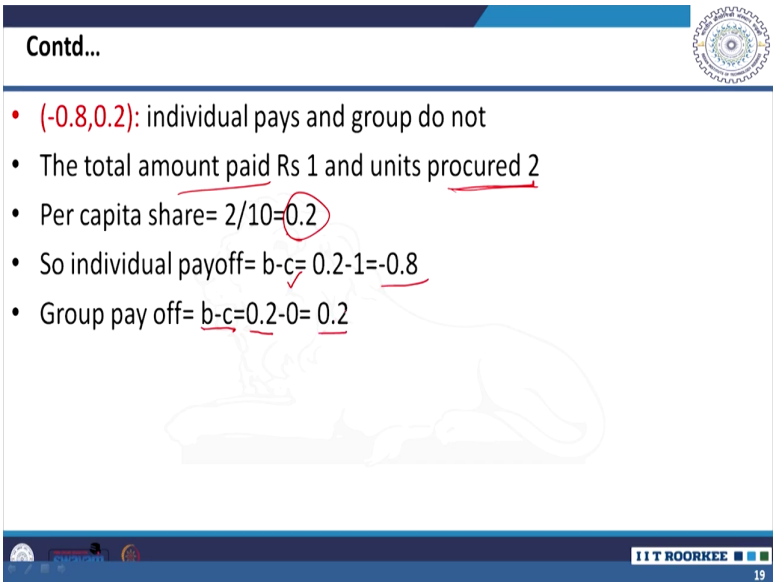

So, we are already done with this we need to think about this the individual is paying, but collective is not paying that means, only one individual is paying. So, in this case the total amount of payment is how many? 1 rupee's obviously, the particular individual is paying. And how many collective units can be procured by exchanging this 1 unit of money? Then obviously, it is 2; 1 unit paying 1 rupees money you can procure 2 units are this collective good

So, now this benefit is to be going to be shared, so the per capita share would be how many the benefit is here 2, 2 units of collective goods and it may must be shared by all the members 10 members. Although the rest of the 9 members they are not paying. So, what is the per capita share now? 2 divided by 10 is 0.2. So, the individual payoff here as you understand that it is defined by taking into account benefits minus costs. So, here per capita share of benefit

out of this collective good is 0.2. What is the cost the individual is wearing? He is paying 1 rupees.

So, how the what is the individual payoff here? 0.2 minus 1 is minus 0.8. So, this is the case where the individual is paying, but rest of these 9 members in the group they are not paying. So, now what would be the payoff for the group? That is the benefit right. So, here again benefits minus costs so the total benefits is 0. 2. And what is the cost total costs the group is paying? Its 0, so it is 0. 2.

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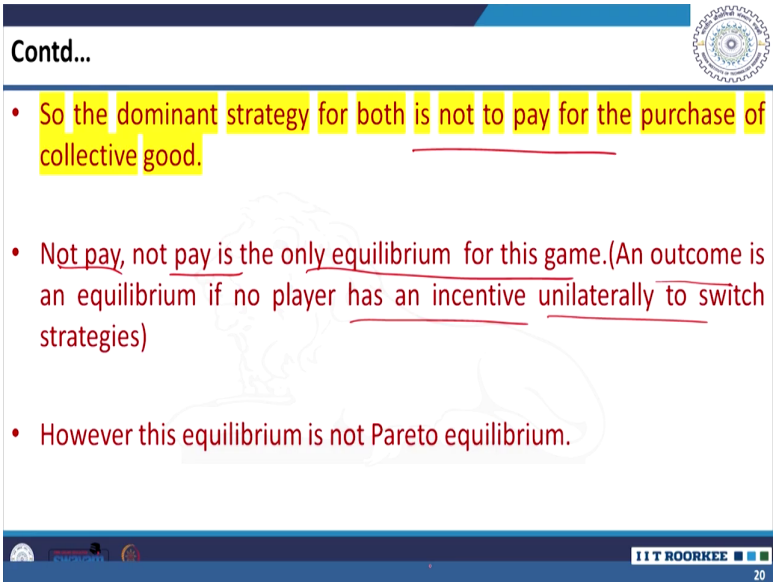

So, in this case the dominant strategies for both these as an individual member and the collective is not to pay because if they are not paying, then they are actually getting more share out of it and not pay, not pay is the only equilibrium in this case. And you can say that how this equilibrium is defined.

So, you can say this outcome is to be in equilibrium condition if no player has an incentive unilaterally to switch about the strategies that means, no player is thinking that I should go for paying. If this is the strategies then this equilibrium condition will not have a cut.

But, however when you are saying that they can actually mutually cooperate and in that case their share would be more would have been more that is why the adjusting scenario for the equilibrium is not Pareto equilibrium.

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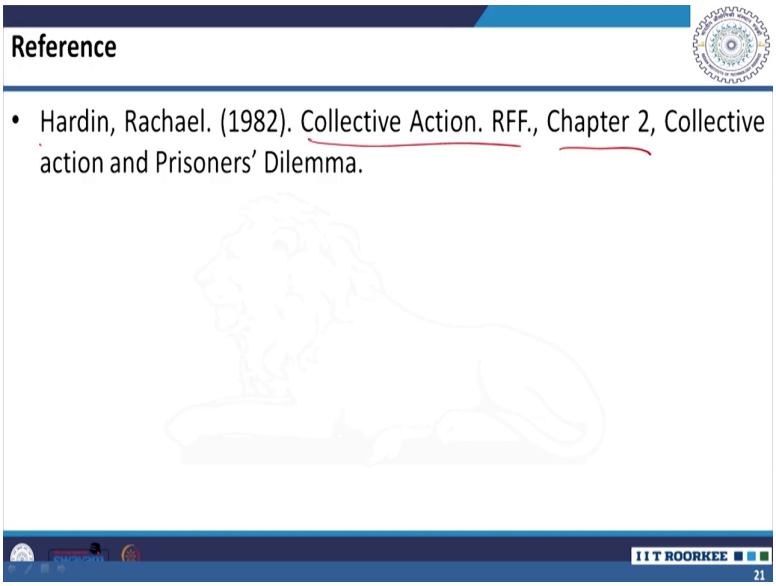

And this is just similar to your collective action problem and the same collective action problem is explain through the this payoff matrix where we are saying it is the dominant strategies that is not to pay and not to pay that means, we are not co-operating. Although if you are going to co-operate we will be getting more benefits right or it is generally the choice

that once would cooperate, but following the individual rationality they are not cooperating. So, this is the same conclusion we are drying in the collective action case also.

So, you need to actually explore these the original contribution, this is the reference for this chapter collective action, chapter 2 and you can follow these book chapter 2 collective action by Hardin, Rachael. So, this is this actually defines that how this collective action problem be explained in terms of this prisoner's dilemma and how the collective action issues and problems can be explained by taking different strategies like game theory is taking.

So, in the next class we will be explaining another theory in explaining this collective action problem that is Ostroms Elinor Ostroms are theory that explain the a kind of solutions to the collective action problem and perhaps this is the latest theory that we will be dealing with in explaining the case of collective actions.

Thank you very much.