Good afternoon, everyone. Thank you so much for being here. First of all, before I start, I wanted to apologize, especially for those who are physically present at the venue that I can’t be there in person. I very recently received an invitation to attend a meeting that was closed on invitation for a discussion about energy transitions in the U.S. that I considered important to attend. And, I couldn’t find any flights that would bring me to the meeting on time. Other than one, for which I am on my way to Newark Airport, literally right now, as you listen to this. But I will, however, join in about 40 minutes to answer your questions. So, if you could please just make note of your questions as we go along. I’d be happy to discuss them live at the end of this talk. So, I’m gonna talk today, about a study that I did while I was working at The International Institute for Applied Systems Analysis, a few years ago. That took a couple of years to complete and finally resulted in the publication,
just a few months ago in nature sustainability, which makes me very happy. And the two main reasons I’m interested to do this talk. The first is, the empirical insights. This is the only the second study I know of. And the first in India that relates the consumption side or the contribution side of air pollution in India to the impact side. And specifically, which households, of what categories of income contribute to different sources of pollution? And, to what extent are they impacted by that pollution in terms of the risk of mortality? And in doing that, I think it’s important from a policy perspective, asking this question, because it allows us to think about consumption as one of the options for mitigation of air pollution, and not just looking at end of pipe controls. And this is one avenue for us to think about how sustainable consumption can be brought into the fore in terms of the solutions to address, not just climate change, but air pollution as well. The second reason, is that to me,
this is a very interesting exercise in interdisciplinary research. And specifically in integrated assessment. So, there was an air pollution group in IIASA. There is an air pollution group. Which many of you I know are familiar with, that run the GAINS Model that I will talk about. And there’s the energy group that runs an integrated assessment model. And does other research on energy system transformations for climate change. And what I was looking with this group, I saw that there was these two different groups had a completely different work research agendas. But they had of course, collaborated to look at co-benefits between air pollution and climate change. But never specifically thinking about the relationship between the contributions from the energy sector to air pollution. And who causes that from the household perspective. And so, I saw these two different groups and the opportunity to build some bridges between them. And pull that off after a few years. So, I think methodologically, it’s an interesting example of applied interdisciplinary research that I think would be nice to replicate in other contexts as well. So, I wanna provide some background.
to air pollution in India. I’m gonna discuss mostly the methodology that we applied in doing this, which I think is the most interesting part to this audience. And then discuss some of the results and the implications for policy. I think it’s pretty clear to everyone in this audience that particulate matter, fine particulate matter has serious health effects and leads to the death of over a million people a year in South Asia alone. And that affects mainly women and children. And this is through various diseases that you’re familiar with; pulmonary diseases, cardiovascular diseases, lower respiratory infections that children face, and many others. The main point I wanted to make about this is that you have to make very, very significant reductions in the concentration levels, in order to really see significant impacts on health. And I bring this up because in India, there has been a focus on residential use of cookstoves.
0:04:30.79 –> 0:04:33.01 as the primary source of air pollution.
0:04:33.01 –> 0:04:34.48 And it is specifically,
0:04:34.48 –> 0:04:36.26 for indoor air pollution.
0:04:36.26 –> 0:04:41.19 And there’ve been numerous studies and programs over decades
0:04:41.19 –> 0:04:42.06 in South Asia,
0:04:42.06 –> 0:04:45.74 to try to create improved cookstoves that burn biomass
0:04:45.74 –> 0:04:47.04 in a better way,
0:04:47.04 –> 0:04:48.56 and have failed for decades.
0:04:48.56 –> 0:04:49.78 And that’s because,
0:04:49.78 –> 0:04:51.95 although they’ve had some kinds of improvements
0:04:51.95 –> 0:04:53.13 in reductions in pollution
0:04:53.13 –> 0:04:56.11 and improvements in efficiency of the stoves.
0:04:56.11 –> 0:04:58.48 They don’t lead to strong enough reductions
0:04:58.48 –> 0:05:01.43 in the concentrations in indoor air pollution.
0:05:01.43 –> 0:05:04.54 So, it’s important to know that there are several other
0:05:04.54 –> 0:05:07.62 aspects of air pollution that are from other sources,
0:05:07.62 –> 0:05:09.273 that affect people’s health.
0:05:10.64 –> 0:05:14.07 Those who are burning solid fuels for cookstoves
0:05:14.07 –> 0:05:15.82 by ambient air pollution that they inhale
0:05:15.82 –> 0:05:17.1 when they leave the house as well.
0:05:17.1 –> 0:05:18.45 And that’s what this paper is about.
0:05:18.45 –> 0:05:21 It’s about ambient air pollution for the most part.
0:05:21.916 –> 0:05:24.01 There’s several different sources in the economy
0:05:24.01 –> 0:05:25.27 for air pollution,
0:05:25.27 –> 0:05:27.05 besides cookstoves.
0:05:27.05 –> 0:05:28.79 Households that don’t have electricity access
0:05:28.79 –> 0:05:30.41 use kerosene for lighting.
0:05:30.41 –> 0:05:32.04 And that is an important source.
0:05:32.04 –> 0:05:34.32 A lot of people don’t know that in urban areas of India,
0:05:34.32 –> 0:05:36.47 where they don’t have access to biomass,
that they use kerosene for cooking as well. So, this is also an urban problem.

Traffic and air pollution of course, is very well known. And I think there’s a stereotype that in cities in India, the traffic burning diesel from buses and single stroke engines are really the main cause of air pollution. But as I show you, it’s much more complicated than that. A lot of industry, as I show the brick kilns over here, is one primary suspect are also major contributors. Of course, power plants as well. And, very often there are times in the year when the pollution is particularly bad, as you can see in these photographs, in New Delhi. Because you have burning of agricultural fields to clear the fields for the next seeding. That takes place next to winter. And so they cause very, very high concentrations of pollution. And those also, are a little bit misleading because they are concentrated in a week or two. And, you know what?

If you look at average air pollution over the year, they tend to be many other sources that dominate the agricultural emissions as well. So, it’s known that globally,
all of these sources contribute to air pollution at PM2.5. But, in different parts of the world, different sources dominate. So in the U.S. for example, power plants and traffic dominate. But in Northern Africa, of course, the dust from the desert as a major contributor. I didn’t mention in the previous slide that natural sources are a very significant contributor as well. Including dust that’s often picked up from construction work as well. We’ll see how that plays a role in India as well. And as you can see on the chart here in South Asia, cookstoves are known to be the largest single source and contributor. But this is perhaps I think to the neglect of many other contributors. And that’s what I wanna focus on in this talk. The air pollution levels in cities, even average annual mean levels are astounding in cities across India. Not just the metropolitans like New Delhi and Mumbai. You’re looking at smaller-medium sized cities that are in the range of one to 5 million as well. All of which, have mean concentration levels that not only exceed the WHO’s guidelines of 10 micrograms per meter cube,
but exceed the National Ambient Air Quality Standards as well, of 40.
And, so the average over the year being so high, it tells you that in particular times of the year, this is even more than that, up to 300, 400 in certain times of the year as well. So, this is a serious problem, and this is only urban.
The focus on rural areas tends to be, indoor air pollution from cookstoves. But as we’ll see in the study, that there are also serious health risks to rural folks from air pollution as well. I wanted to briefly mention the New Delhi study, ’cause I think it was insightful in terms of revealing the different sources of pollution. This is a study that was done by the air pollution group at IIASA using the GAINS Model. And, it shows that if you look at the different causes of air pollution in New Delhi; that’s a mix of sources that really, all of these sources contribute a fair amount. So, even dust from kicked up by construction work and by traffic is a significant component. Burning of bodies and fireworks are a significant component. Trash burning is extremely important. Residential cookstoves, even within and around New Delhi are a significant.
And I said, this also includes kerosine and not just solid fuels. Power plants to a small extent. And a lot from agriculture, that is in the neighboring regions around Delhi. A lot of the pollution is from secondary inorganic PM. And then, this agricultural waste burning, as I mentioned, is just a small component. So really, if you look at all these sources, over 60% of air pollution in Delhi is from sources outside of the city center itself. And that's why it's really important to look at flows of air pollution across the country. Let me just give a brief overview of the literature, especially with relation to environmental justice. Because there has been a growing number of studies recently across the world, that try to understand this, the idea of our people facing a disproportionate exposure to air pollution. And so, we know that people who have studied find that air pollution is a cause of health inequality in developing countries, by and large. And we find that at a global scale. And those health inequalities also have been associated with socioeconomic disparities. So, people of higher income levels suffer less health impacts from air pollution,
than lower income levels. And this seems to hold in a lot of parts of the world, even in Europe. So, this is not just a developing country phenomenon. There are some exceptions such as in France, certain parts of Paris. You have rich neighborhoods that also have very high concentrations. But by and large, there seems to be a growing environmental justice concern about the relationship between air pollution, health inequality and socioeconomic inequality. We’ve seen this also in terms of international trade, that if you think about the air pollution that’s exported, by importing products from countries where the air pollution impacts are felt. That also, is an important consideration. And China in particular, falls in that category because they provide the manufacturing capacity for large part of international consumption, by and large. There’s only one study that I know of, that’s the precedent for the one that I’m talking about. Which is a study in the U.S. that has actually looked at inequity in the consumption of goods and services. And found that there is a racial and ethnic dimension to the disparity in air pollution exposure. But this study also only goes so far
as to look at consumption in relation to air pollution exposure for different household groups across the country. In our study, what we do is, we go further and look at mortality impacts. That is, we factor in the differential vulnerability of people to exposure, due in part to the different income levels. Which provide them with the ability to adapt or avoid different levels of air pollution. So, that’s the unique aspect of the study that I’m gonna show you. Which is really looking all the way from consumption and sources, down to mortality risk. So, the question we asked, is can we attribute pollution sources to households through their consumption patterns? So the first challenges that the GAINS Model, The Air Pollution Model, know air pollution sources in terms of sectors. So, different industrial sectors, the transport sector, the household sector. But, how can we take that back, trace it back further to different household groups and their consumption patterns? So, now we need to understand and trace the different products and services from the sectors back to households.
So that was one big challenge that I wanted to address. And that was one of the bridges that we wanted to build between the air pollution group and the energy group.

And the second is that, Can we incorporate households vulnerability in translating exposure to mortality? 'Cause we also wanted to account for the effect of income.

Here we didn’t have a lot of empirical evidence, but we did apply one paper that had some quantification of the role of income, but this was at a national scale.

But we applied that to households across India as well. So, putting those books together, we found that it would be useful to organize households in terms of the income level; because the income level defines both consumption patterns, which we can then relate to industry. And income levels define also vulnerability.

And so that would fall, it was a good organizing principle, in order to look at households and the both sides of the pollution equation. And so that’s what we did.

We looked at household deciles across the country. So, here is the complex modeling environment.

And I wanted to spend a little time going through this. So, if I start on the impact side,
which I think most of you might be better, more well versed than I am.

So, this is not my primary expertise. So, we looked at mortality by the decile. And the main innovation was to apply this vulnerability by decile. As I mentioned, higher income groups have lower vulnerability. And then we used standard concentration response functions using spatially explicit PM2.5 concentrations, the grid level. And then exposure by age, sex and location; urban or rural, and by state. In order to determine the mortality associated with a given concentration at different geographic parts of the country. Now, what was important here is the caveat, which is that, while we know the distribution of income across states in India, the surveys don’t give us a reliable enough estimate of the distribution of income within a state, except urban and rural. So, how are the different income deciles distributed within rural India, in a particular state? We don’t quite know. So what that meant, all rural residents in any given state.
had the same exposure. We can’t differentiate exposure based on income level within urban-rural regions within a state. However, we do have differential exposures in different states in urban and rural areas, based on a number of factors; including where pollution sources are located. How income is distributed, et cetera. As I’ll mention a little bit more later.

On the contribution side, the contribution pathway was where we needed an innovation to link the household survey and consumption by decile to the final sectors, which the GAINS Air Pollution understands. So, let me just spend a minute on this intermediate section.

The three sources of pollution from a consumption perspective. There’s the direct use by fuels. So, that’s cookstoves and heating fuels that are burned directly in the household, As our scope one. Emissions from the IPCC’s language. And there’s transport and electricity is also use fuels and household expenditure on fuels. The fuels being gasoline, diesel and electricity. But the emissions are elsewhere. So, that’s scope two emissions. And then the third, is where the consumed goods and services
and lead our trigger air pollution through the manufacturing of those products and services. And so, that’s where we use extended input-output analysis. A multi-regional in-product put analysis that ultimately counts for trade. To be able to link household survey products to industry sectors. Now, this mechanism I had already developed in my own research. That is, to be able to do household footprinting of energy use for different products. But what we had to do was to extend this, to create BM2.5 satellite matrix. And the satellite matrix that we had to map are input-output sectors directly to the sectors in GAINS. And that was one of the bridges that we had to build. And with that, we were then able to create a population weighted national, PM2.5 concentrations based on all of the sectors. But then attribute that to deciles, income deciles in the country. Based on the basket of goods and services that each decile consumed. So, as you can imagine, lower income groups tend to consume less stuff, but they’re using a lot more direct fuel. Whereas higher income groups
don’t use any direct fuel at all.
They use electricity.
And of course, they drive cars,
but they consume a lot of stuff.
And so, that’s how we wanna kind of see
how they play out in terms of the net effect
of air pollution from these different sources.
Just a quick deep dive for the GAINS Model.
Again, I think a lot of you are familiar with this.
They have a very detailed representation
of point sources of pollution across the country.
Including a spatial representation
from all the sectors in the economy.
And they also model end-of-pipe solutions;
pollution control, their different costs.
The greenhouse gas emission applications as well,
and a set of different air pollutants.
And they have the ability to define scenarios,
scenarios of control technologies,
applied to different activities in the economy.
And based on the emissions factors
and links to a dispersion,
atmospheric dispersion model.
You can see the effects of controls
on pollution concentrations in different parts
of the country.
And then, look at the effects on mortality
using standard dose response functions
from the Global Burden of Disease.
And then, you could iterate in order to determine if we had to limit the number of the extent of health impacts. What scenarios of pollution control could bring us there?

So, we will be utilizing some of this scenario technology in this study as well.

So, the direct sources, as I mentioned.

It was important to understand what households use what kind of cooking fuels.

Now, we have this data from household surveys.

So, we have an understanding of the demand curves, if you will,

for different types of households in urban and rural areas,

and off different income levels.

And understanding at what price point they would switch from gas back to biomass, for example.

So, we have a detailed understanding of what households use what kind of fuels.

But we had to do a little bit of work to understand the travel modes for different households,

at different income levels.

Who travels by bus and by rail? And who has a car?

In order to determine the indirect impact of air pollution through the transport means of the vehicles that they use.

And the same with electricity,
depending upon how much electricity households use.
The power plant in GAINS would tell us the extent to which
they cause air pollution in power plants,
through their use of appliances and electronic gadgets at home.
So, that was the two main direct sources.
The scope one and scope two,
and then the scope three,
is this household footprinting technique.
Which is a very large number crunching exercise.
Where you have to link household consumption surveys
and map them into a certain industry standard category
called COICOP used in Europe.
And match them to the sectors in the industry
and put output database,
match prices and other fun stuff,
that allows you to create a total embodied energy
that’s induced by every unit of consumption
from different products and services.
So like I said,
this is a methodology we’d already developed before.
And the idea was just to link this
to the air pollution model.
One last thing on methodology,
just to provide some sense of the results.
This is a slightly old,
but illustrative graph of the average air pollution
across the country.
And the point is,
The location doesn’t matter.

You’re seeing here that the average concentrations in India tend to increase as you go northward. And this is because of temperature inversions, by and large. And also because there is a very high concentration of polluting power plants. So, mainly the coal belt is largely in the north and the Northeast. And so, the combination of those make it unlikely for people who live in the north.

You can imagine that the distribution of people, if it’s the extent to which people are rural and poor, and live in the north, they would face a higher level of pollution, all as equal.

You also can see that the urban centers, the little dots spread across the map are also much higher concentrations of pollution, because of additional sources of pollution in the cities and in the urban areas.

And that also tells us that the distribution of population in different urban areas also, and their income distribution reflects, or has an impact on who ultimately faces mortality from all of these combined sources of air pollution. We did create this pollution inequity index, which is mortality risk per unit of contribution to PM concentrations.
0:22:51.66 –> 0:22:52.73 It’s a bit of a mouthful. 
0:22:52.73 –> 0:22:54.58 And perhaps not intuitive. 
0:22:54.58 –> 0:22:55.76 But the reason why we did that 
0:22:55.76 –> 0:22:57.65 was we can then compare this index 
0:22:57.65 –> 0:22:59.16 at different income levels. 
0:22:59.16 –> 0:23:02.31 In order to look at the relative injustice, 
0:23:02.31 –> 0:23:03.143 if you will, 
0:23:03.143 –> 0:23:04.25 for different income groups. 
0:23:04.25 –> 0:23:06.98 The extent to which they are facing higher mortality 
0:23:06.98 –> 0:23:08.49 per unit of their contribution 
0:23:08.49 –> 0:23:10.91 to the source of that mortality. 
0:23:10.91 –> 0:23:13.11 So, that’s what we used as well 
0:23:13.11 –> 0:23:15.423 to try and illustrate the extent of inequity. 
0:23:17.36 –> 0:23:19.36 Okay, so now let me move to the results. 
0:23:21.03 –> 0:23:24 Let me start with discussing the contributions, 
0:23:26.46 –> 0:23:28.52 So, let me start with the leftmost average bar. 
0:23:28.52 –> 0:23:30.2 This itself was insightful. 
0:23:30.2 –> 0:23:33.59 So, this is the total average PM concentrations 
0:23:33.59 –> 0:23:36.29 and their broad source categories. 
0:23:36.29 –> 0:23:38.55 So, the lowest one is household cooking fuels. 
0:23:38.55 –> 0:23:42.43 So, this is primarily solid fuel burning. 
0:23:45.29 –> 0:23:47.57 And this is already something that we learned new. 
0:23:47.57 –> 0:23:49.17 So, we generally have the impression 
0:23:49.17 –> 0:23:53.74 that 30 to 50% of PM2.5 in India, 
0:23:53.74 –> 0:23:55.713 it comes from solid fuel burning. 
0:23:56.88 –> 0:23:58.32 But if you look at this green bar, 
0:23:58.32 –> 0:24:01.6 this is including scope two and scope three emissions. 
0:24:01.6 –> 0:24:06.05 And, so this household consumption other than cooking 
0:24:06.05 –> 0:24:07.52 and heating fuels, 
0:24:07.52 –> 0:24:11.763 is actually a much higher than cookstoves.
So in fact, it’s about 40 to 60% just if you look at household consumption. So overall, the indirect household consumption actually is causing more overall pollution than does cookstoves alone. The other interesting thing, to see that these non-household consumption. So, this is government expenditure called industrial manufacturing; things like defense, as well as capital formation. That’s not included in household consumption, contributes a fair amount, of the order for a quarter of total air pollution. And then a big chunk of air pollution is from natural sources, like dust, as well as trans-boundary sources. So, even from Pakistan, for example. So, all the solutions that we have got, that I’m gonna show you in this scenarios can really only addressed 50 to 60% of air pollution in the country. So, there’s a limit to which we can reduce mortality just from this study; from reducing air pollution from household consumption in particular. Now, if you look at the right hand side, we’re showing you by decile with increasing income moving to the right.
The different sources of air pollution and their contributions. So you can, it's intuitive to know that the lowest income households, their biggest contributor is cooking and heating. Whereas if you look at the top decile, they don't cook with biomass very much. You still have some biomass use because there are some rural folks who still fall into the top decile. Even though it's dominated by urban residents. And you see that there's, electricity usage is significant. So that's power plant emissions. And passenger transport, which is very high because people all own cars over here. And so their individual per capita emissions have very high. What was very surprising to us, is the extent in the contribution of food and food waste. This is food production. Things like fertilizer use and nitrous oxide and ammonia. As well as the fossil use for machinery and transport, and agriculture, is all reflected in the light green. Whereas the dark green is reflecting food waste. That's the burning of food waste, and that's thrown out in the open. As well as the municipal waste burning for incineration. That's a significant contributor
and we attribute waste to households in proportion to their consumption of food. And that’s why this is proportionate to the food related air pollution. And finally, the other stuff in terms of products and services; actually it was surprising to us to be at a smaller contributor than we thought. So clearly, there’s here a trade-off. So, low-income households are contributing to air pollution through their cookstove use. And high-income households are contributing through their other indirect use; food, transport, electricity and other stuff. Just a quick look at urban and rural differences. So, if you look per decile. This is the contribution of urban households to the deciles in aggregate. And, clearly you see that the highest deciles tend to contribute the most from urban areas because rich people tend to be in urban areas in India. That’s really what we’re showing. Whereas in rural areas, you tend to have fewer people contributing to the higher deciles. The other thing is to, if you look at it per capita basis; so not looking at the aggregate contribution to deciles. You notice that in urban areas, by and large,
as you go, as you increase your income level, your overall contribution to air pollution isn’t increasing very much. It’s really in the highest decile where you see the biggest change in consumption levels. And therefore, the biggest impact on air pollution. Whereas in rural areas, there’s a steady increase in air pollution. Despite the fact that there is a reduction in cookstove use. And, so that tells you that the consumption is offsetting the reduction in the air pollution from cookstoves. Even in rural areas, where cookstove use dominates. So, now we move a little bit more to the impact side. So, now we’re looking at contributions versus mortality. If you just focus on the black lines here. The highest deciles are to the right. So, the contribution curve is the one sloping upward. And you see that higher income groups contribute significantly more to PM concentrations than do lower income groups; by a factor of three or so. And if you look at the dotted black line, that is showing you the mortality impacts. So, the lowest income group based on mortality impact for about 200 premature deaths per a hundred thousand. This is ambient air pollution alone. Compared to less than one.
0:28:55.12 → 0:28:57.99 That’s a factor of four difference in terms of the mortality
0:28:57.99 → 0:28:59.62 going in the opposite direction.
0:28:59.62 → 0:29:01.04 So you can see here,
0:29:01.04 → 0:29:02.84 this is a kind of headline figure
0:29:02.84 → 0:29:06.74 in terms of the inequity that households are
0:29:06.74 → 0:29:09.93 in low-income decile are contributing so much less,
0:29:09.93 → 0:29:11.353 but facing so much more.
0:29:12.856 → 0:29:13.689 And this is from all different sources.
0:29:13.689 → 0:29:16 This is separate from the indoor air pollution
0:29:16 → 0:29:17.26 they face from cookstoves.
0:29:17.26 → 0:29:18.86 This is just looking at ambient.
0:29:20.562 → 0:29:21.55 And the blue and the red lines are showing you
0:29:21.55 → 0:29:26.29 the rural and urban households in particular.
0:29:26.29 → 0:29:28.943 And you’ll see that they converge.
0:29:31.122 → 0:29:32.46 So, the rural households are dominating
0:29:32.46 → 0:29:34.062 the low-income households,
0:29:34.062 → 0:29:34.895 and the urban households are dominating
0:29:34.895 → 0:29:35.95 the high-income households,
0:29:35.95 → 0:29:37.37 as I showed you earlier.
0:29:41.01 → 0:29:43.76 (table creaking)
0:29:45.679 → 0:29:47.135 Now, we want you to look and isolate
0:29:47.135 → 0:29:48.964 some of the different sources of pollution.
0:29:48.964 → 0:29:51.14 So, we developed two scenarios.
0:29:51.14 → 0:29:54.3 Which we posed as sort of clean up scenarios.
0:29:54.3 → 0:29:56.82 So, you have the clean cookstoves scenario,
0:29:56.82 → 0:30:00.21 where holding everything else constant.
0:30:00.21 → 0:30:02.812 We switched everybody to clean cookstoves.
0:30:02.812 → 0:30:04.643 Which means either electric cookstoves,
0:30:06.115 → 0:30:07.29 whose power plants were all green.
0:30:07.29 → 0:30:12.29 So, they add literally no emissions from the stoves.
But we kept everything else constant.
And the other scenario, we implemented end-of-pipe solutions on all other sectors, except cookstoves.
To the maximum extent of available technologies globally.
So, actually we used Germany.
And, so technology frontier in Germany.
For example, Euro 6 norms for vehicles,
If I remember correctly.
So, very, very stringent controls,
not really considering costs in this particular study.
And applied those.
So, what this allowed us to do,
really was to isolate the air pollution impacts and their distribution from these two sets of sources.
So, in the clean cook source scenario,
when I show you the results in red;
you will see the impact,
the distributional impact of the scope two and scope three.
Which are dominated by higher income groups.
Whereas in the MCO scenario,
which you gonna see in blue;
you’re gonna isolate the distributive impact of dirty cookstoves through ambient air pollution.
So, first I’m showing you what I think is already a pattern.
From the previous slides.
Which is this the contributions.
So, their reduction that you get from the clean cookstoves are shown in red.

And from the end-of-pipe in the rest of the economy in blue.

And you see that the contributions reduce the most for lower-income groups, when you impose clean cookstoves.

Which makes sense because they are the higher users of dirty cookstoves.

And like I mentioned, the rural households and the rich rural households still use biomass to some extent.

So, you still have a little bit of that.

But then if you look at the contributions from the other sectors, because lower income households don’t consume a lot of stuff in terms of electrical gadgets or they don’t have cars.

And they don’t consume a lot of stuff.

Their reduction that they face in terms of contributions, not face the reductions in their contributions is lower than the reductions in contributions for higher income groups who consume a lot.

Now, if we look at the impact side. This is the key insight in this study.

The avoided mortality from the clean cookstove scenario is predictably much higher for lower income households.

They’re located in areas where there’s more cookstove users.
And so, the ambient air quality is much worse from the cookstoves. So, that’s predictable. But what was not expected, is that the contribution from the ambient, from the other sources; industry, transport, electricity, also falls disproportionately on these lower income households. And that’s in contrast to the contribution. So this is the impact side, and this is the contribution side. And you clearly see how the, it’s the other consumption that is disproportionately affecting lower income households from ambient air pollution. And that is really the main insight from the study that we were not expecting. And as I mentioned, this has to do with where points offices are located, in relation to low-income households. It has something to do with the differences in urban and rural populations across the country. As well as this temperature inversion in the north. All of these contribute to this imbalance. If you look at this pollution inequity index, it may seem a little counterintuitive. But the red dots are showing you the inequity in just the other sources.
And that’s why you see here. The pollution inequity is much higher in this scenario where you have clean cookstoves. Because the ambient sources of their pollution are causing higher mortality disproportionately on lower income groups. Whereas the pollution inequity index is not as steep in the case where you clean up the rest of the economy and leave dirty cookstoves. So, that’s really the key, the point here. Now, I wanted to make sure that we put it into context, mortality associated with ambient, compared to indoor air pollution. Because it still remains the case, that indoor air pollution really is the biggest problem in terms of mortality from air pollution. (creaking sound) Is the order of magnitude higher deaths that are caused by indoor air pollution? As you all know, the concentration levels are associated with cookstoves indoor. We take a 300 micrograms or more per meter cube. And so therefore, if you just look at the overall introduction in mortality from clean cookstoves, accounting also for indoor air pollution. Of course, you see that the lower income groups benefit the most.
But that’s really mostly from the indoor air pollution. The inequity from the outdoor air pollution in blue, you’re still seeing as falling disproportionately on lower income households. You’re just seeing that the in absolute terms, it’s still a lot less than indoor air pollution related deaths. So, we wanted to make sure that we’re not saying that clean cookstoves aren’t as important to clean up, due to indoor air pollution. In fact, they still remain the most important mitigation measure. So, I just wanted to put that into context.

So, the cookstove contributions, we found some interesting insights. Namely, that the contribution to ambient air pollution is 40% of that, of the other sources; that is triggered by household consumption. And that’s ignoring transplant resources, natural sources, as well as government related pollution. As well as capital formation. So, that itself is an insight that we need to think about the household contributions to air pollution from other sources. We found that lower income households tend to face a disproportionate mortality risk burden.
from ambient air pollution.
And this has to do with the location of point sources
around the country and the distribution of populations.
But, despite all of that, really clean cookstoves are an important mitigation measure because of the impact on indoor air pollution.
But overall, I think the importance of this study is really to think about in the broader context, indoor air pollution-
um, sorry.
consumption as a means of mitigation of air pollution.
There’s a growing interest in the climate mitigation literature to focus more on demand side options.
And therefore, it’s important to think about the co-benefits from sustainable consumption as well.
And you don’t really think about that very much.
But there’s a broader theme here. That we tend to export pollution associated with our consumption in so many different ways.
Climate change is an obvious one where we export them
to future generations.
And from richer countries to poorer countries.
That’s been shown by the IPCC.
Time and again,
We see that with waste, of course. We export our waste to different countries as well. But we’re also seeing that in terms of air pollution, more and more, now across countries and within countries as well. And so this the main result from this study. And so lastly, I wanna point out on the methodological side. I think that this study is generalizable in terms of the approach. This could be applied to really any economy. If you have the analytical framework to calculate your footprints. And you have an air pollution model with an atmospheric dispersion. It’s possible to do this kind of analysis and really have any context, just by replacing the data. And I think that would be something that would be useful to do. As I mentioned, just to think about sustainable consumption more broadly. So, thank you for your attention. And now, I will be joining you live in order to answer questions that you may have. Thanks very much. Thanks, Dr. Rao, for this very wonderful talk. And actually, all your questions, Dr. Rao.
As we seen them.
And, as you may find out.
During his talk, some of your questions has been already answered.
Like, the DTR zone, the pollution inequity effects, or whether his approach could be applied to other different countries or settings. But collectively, I think your questions are falling within the two things.
We can ask Dr. Rao to answer them live. And in the meantime, for our, the other online audiences, if you do have any questions, please feel free to post your questions in the chat box and we will do the Q & A as well.
So, Dr. Rao, if you can unmute yourself, then maybe we can start the Q & A section.
Sure. Hi. I hope you can hear me okay?
Yeah, we hear you very well. Great.
Thanks for joining us this way on the (indistinct)
So, I think before the whole audience can ask questions, we can first start with the students, the questions they have.
The first type of questions, generally about relationship between air pollution in the country and some of the detailed questions, for example, students are wondering, what’s the link between the global versus local actions?

And among the different countries; Do development rise play in a role in determining the inequity in the air pollution exposure. And also, in terms of the content of impact. Data that also recent COP26, address those issues indirectly or maybe completely ignore them.

So, Dr. Rao? Yeah, that’s a very interesting set of questions around the link between climate change and air pollution.

And kind of a global, the global imperatives versus the local imperatives of feeding up air pollution. What’s interesting about the cookstoves, is that the biomass cookstoves have a lot of their own emissions; short-term forces that cause climate change. And they’re extremely inefficient. When we switch over to even gas-based stoves; even though gas is produced in fossil resources and causes CO2 emissions. The net effect on climate is actually almost negligible.
Because the efficiency of gas stoves is so much higher and you avoid all of the other short-term climate forces, the net effect is almost negligible. So in other words, to switch over to LPG stoves, which is currently the most popular substitute is not a climate issue. Which is good, because people often saw that as a potential conflict. If you will, to electric stoves, which I do think is the long-term solution. Initially in India, because we have a coal dominant electric sector. It would be an increase in emissions, CO2 emissions in the short-term. But in the long-term, as you decarbonize the electric sector, of course, the idea is that the electric stoves will be zero carbon. So, that is the immediate impact of cookstoves and climate. Broadly, this topic is not really addressed so much in the sort of co-benefits that richer people tend to look much more at transport; because that’s a clear co-benefit, reducing air pollution and reducing emissions in decarbonizing transport. So, I do think cookstoves need to be brought into the equation a little bit. Because there’s a strong development core benefit of pursuing cookstoves.
And potentially, a climate benefit in the long-term with electric cookstoves. And I don’t think there has been any focus on this in the negotiations. We far removed from it really. It doesn’t really factor in. But I do think, a lot of the climate policy in developing countries needs to be looked at as development first. That is, looking at development policies entry point, and doing that in a manner that’s climate friendly. In that kind of a conversation, looking at cookstoves is really important. (cricket chirping) Thanks, Dr. Rao.

The second type of question is, you have shown there is very vast differences in terms of the deciles the least, but they suffer the most from the air pollution related mortality. And so, the students are wondering. Are there any policies to effectively check the status quo? So, how can we reduce this inequity? Particularly, through consumption. Examples, these students are wondering, what are the most cost effective and last floating options that work? How do we incentivize the behavioral changes
0:43:21.86 –> 0:43:23.113 for people to,
0:43:24.026 –> 0:43:25.07 for example, you mentioned cookstoves.
0:43:25.07 –> 0:43:30.07 How can we incentivize people to use more clean cookstoves
0:43:31.697 –> 0:43:32.53 and a whole,
0:43:32.53 –> 0:43:36.393 also you showed that for the high-income population;
0:43:37.4 –> 0:43:39.32 accurately, the food and food waste
0:43:40.796 –> 0:43:44.78 has the kind of the large contribution to the air pollution.
0:43:44.78 –> 0:43:48.763 So, how can we reduce this urban food waste?
0:43:50.053 –> 0:43:50.886 And then lastly,
0:43:52.006 –> 0:43:53.805 What are the key policy challenges
0:43:53.805 –> 0:43:55.928 that you could have going on?
0:43:55.928 –> 0:44:58.44 Do you know whether these policy
0:44:58.44 –> 0:44:01.283 has been achieved on so far?
0:44:04.055 –> 0:44:04.888 <v ->Y eah.
0:44:04.888 –> 0:44:05.73 So, the policy or the situation,
0:44:05.73 –> 0:44:07.56 as with a lot of climate issues.
0:44:07.56 –> 0:44:09.92 There’s a big disconnect between reality
0:44:09.92 –> 0:44:13.101 and what we see in our models and analysis.
0:44:13.101 –> 0:44:15.38 So, seeing air pollution as a consumption issue,
0:44:15.38 –> 0:44:17.123 is very far removed from policy.
0:44:18.238 –> 0:44:20.838 I think air pollution policies are focused a lot on,
0:44:22.658 –> 0:44:23.491 like I said,
0:44:23.491 –> 0:44:25.496 in end-of-pipe solutions.
0:44:25.496 –> 0:44:28.72 And those are really still the main focus of policy.
0:44:28.72 –> 0:44:30.69 Cookstoves in particular,
0:44:30.69 –> 0:44:34.508 even just simply coming up with a cost-effective
0:44:34.508 –> 0:44:36.65 alternatives has been very, very difficult.
0:44:36.65 –> 0:44:38.173 As I mentioned in India,
0:44:40.194 –> 0:44:41.06 the main substitute has been
LPG, liquid petroleum gas stoves.

And there has been a very successful experiment in the last few years by the Modi government. Where 15 million households actually were given free cookstoves and one cylinder. And that was seen as a major success, especially in urban areas.

But, we found from research subsequent to that program, that people didn’t end up using the gas stove so much. And the reason is that, even though they got a free stove, the fuel was too expensive. And the fuel has not been subsidized enough.

In fact, the prices have been liberalized over the last decade.

So, that’s the problem. We need to subsidize both the fuel and the stove. If you really want a sustained shift over to other fuels. Because people may be familiar that people stack stoves;

they have multiple stoves;

and they use the one that’s cheapest.

So, the policy solutions are not successful yet.

Let alone, look at consumption.

In the area of consumption,

I think behavioral change to reduce consumption;

I mean, we can think about that as being extremely difficult.

in any context.

What’s more important maybe from the study, is to focus on food and food waste
0:45:55.63 –> 0:45:56.933 as an air pollution issue.
0:45:57.968 –> 0:46:00.199 Which is not often viewed that way.
0:46:00.199 –> 0:46:01.91 So, thinking about cleaning up waste;
0:46:01.91 –> 0:46:03.373 not only for recycling,
0:46:04.276 –> 0:46:06.34 but to control how it’s disposed off
0:46:06.34 –> 0:46:08.338 and to prevent its burning,
0:46:08.338 –> 0:46:10.146 or doing controlled burning.
0:46:10.146 –> 0:46:13.06 Having incineration in an organized manner in cities,
0:46:13.06 –> 0:46:16.027 where they have controls for pollution.
0:46:16.027 –> 0:46:19.064 That, I think is probably the insight that’s most important
0:46:19.064 –> 0:46:21.664 from this study with regards to policy more broadly.
0:46:24.75 –> 0:46:26.43 Thanks Dr. Rao for sharing that insight
0:46:28.025 –> 0:46:29.803 We do have a few minutes left at that.
0:46:31.094 –> 0:46:32.064 Any of our,
0:46:32.064 –> 0:46:33.94 also online audience want to ask a question,
0:46:33.94 –> 0:46:36.98 please feel free to post the question on the chat box.
0:46:36.98 –> 0:46:40.123 Or if you want to ask directly,
0:46:41.036 –> 0:46:42.273 feel free to unmute yourself.
0:46:44.451 –> 0:46:45.551 And before we move on,
0:46:47.502 –> 0:46:51.823 I even had another question regarding this type of research
0:46:52.682 –> 0:46:54.433 that Dr. Rao,
0:46:54.433 –> 0:46:58.867 you showed us that the very drastic differences
0:47:00.29 –> 0:47:03.55 in the low-income country,
0:47:03.55 –> 0:47:06.1 low-income communities versus the high-income communities
0:47:06.1 –> 0:47:07.403 in terms of the inequity.
0:47:09.124 –> 0:47:14.124 So, this type of Pollution Equity Index.
0:47:15.916 –> 0:47:19.634 You mentioned that it can be applied to different countries.
So, I’m particularly wondering, do you have any plans for future work, like, focusing on not just India but in the United States? Because, one, the recent researchers found that actually the food production consumption also contributes, also a major contribution to the ambient air pollution due to the house impacts in the United States as well. So, I’m thinking about if you can apply this Pollution Equity Index to the United States, what could be some of the major messages that you can wave for policy makers? Yeah, actually there is a research group. I had mentioned it, I think in part of this talk. A Tesla metal paper, it’s in Phoenix. I believe Phoenix, where they have done a very nice study that does this relationship between consumption and air pollution. And so, we do have research groups and the data are available in the U.S. to do this analysis. The missing piece there, in that study was to take exposures at a especially granular level and convert that into mortality risk.
So, that’s the part that we’d need to be done. And then, one can look at pollution equity, not just in terms of exposure and consumption comparisons; But mortality consumption. And I think that would be a useful step to do. I don’t personally, have access to those data. I’m on energy side. I am working in fact, on residential energy in the U.S. at a detailed spatial granularity, with spatial granularity. And it would be an opportunity to team up with air pollution folks to… Kyle is an example of it himself. (chuckles) To look at that kind of inequity or looking at mortality risks for specific communities and comparing it to consumption levels. And I think that is certainly something that’s worth doing, and possible for us to collaborate and do in the future. Excellent, yeah. I think that’ll be a very emerging field for a lot of researchers like you. Working in handy site for researchers in the air pollution field and for our students and all our audiences working maybe in the environment of agricultural food. So, thank you, Dr. Rao. I don’t see there’s,
but there’s one question.

I see one more question in the chat.

Yes.

Okay, Richter Autry. Yeah.

So, Richter Autry;

Do you think it would be more efficient to enrol

with the private sector in bringing about a faster

and more efficient change?

Mm.

Um...

I think the private sector will be undoubtedly necessary

for the implementation of these policies.

They will be the provider of these technologies,

for sure.

I think, it also would require

as much government regulation as well to guide investments.

I think for example,

with norms for automobiles standards.

Those are generally regulated wherever you go.

It’s something that has to be regulated

’cause there’s not much incentive.

There’s no private benefit associated

with the air pollution reduction.

And so, it has to be guided by policy.

But I think,

there could be,

it has to be asked whether there’s enough incentive

for the providers of those technologies

to enter the market for them.
So, that definitely is an issue.

I think with cookstoves, it’s not necessarily an issue. There’s plenty of market incentive to provide, to sell these stoves. The government has to just subsidize them. Make them affordable. And for other end-of-pipe solutions; cleaning up waste, for example. That is another externality. It’s hard to see just the private sector leading that. But I do think they have to be involved in terms of providing the technologies. But, I think regulation is really the answer in terms of making a shift today.

Thank you, Dr. Rao.

Yes, I think this speaks to the very core of what the purpose of the caption the house constitution, is to train the next generation of leaders who might be the policy makers than to have us tackle on this issue. So, thank you for Vanessa.

And thank you so much for answering the Q & A. I don’t think there’ll be other questions. And so, maybe we can check out. We can have five minutes earlier. And thank you all for joining us, in person and online.

Thank you.

I think we can give a round of applause for Dr. Rao.
Thank you so much for tolerating this suboptimal form of communication, but I appreciate it.

Bye-bye.