

# EMISSIONS FROM IRRIGATION PUMPS IN SOUTH ASIA: THE CASE OF BLACK CARBON

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**Role of solar irrigation pumps (SIPs) in clean energy transition in South Asia**

# BACKGROUND

- High dependence on agriculture in South Asia

2020	Bangladesh	India	Nepal	Pakistan
Employment in agriculture (% of total employment)	37.7	41.5	64.5	35.9
Source: ILO Modelled estimates				

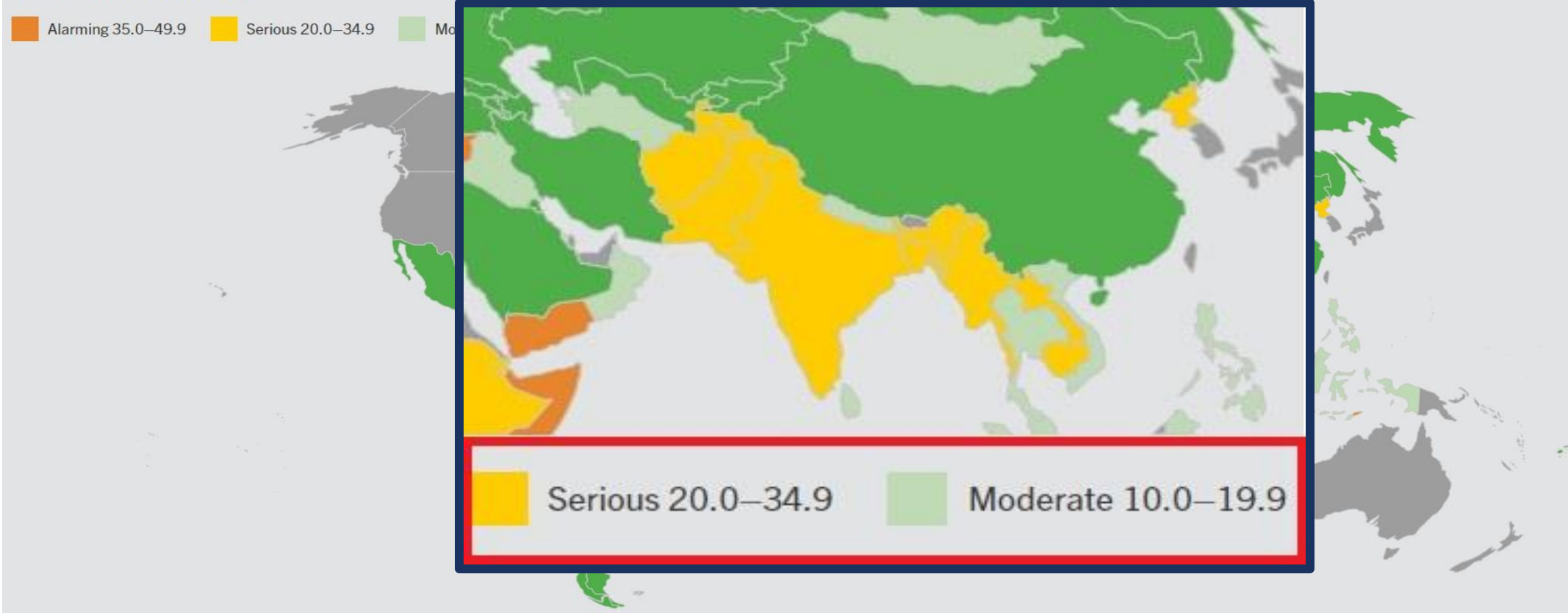
# BACKGROUND

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## 2020 GLOBAL HUNGER INDEX BY SEVERITY

Interactive World Map



# BACKGROUND

- High dependence on agriculture in South Asia
- Also a region with among the highest number of undernourished people in the world
- Agriculture is heavily dependent on groundwater for irrigation
- Primarily obtained through diesel operated or electricity operated irrigation pumps
- It is estimated that South Asia has 25-30 million irrigation pumps
- Availability of irrigation water will be essential to contain the impact of global warming on food production in South Asia (Lal, 2011)



An irrigation pump in Saptari, Nepal

# THE CASE OF BLACK CARBON (BC)

- To demonstrate the impact of diesel irrigation pumpsets in the Indo-Gangetic Plain
- Argue that a shift towards a non-polluting source would have significant implications for climate mitigation efforts without compromising on food security and would also be beneficial for health outcomes

# BLACK CARBON (BC) EMISSIONS

- Black carbon emissions are released through the incomplete combustion of fossil fuels, such as diesel
- Linked to human morbidity and premature deaths (Anenberg et al., 2012)
- Contribute significantly to global warming (Ramanathan & Carmichael, 2008)
- Contribute to atmospheric brown clouds (ABCs)
  - implications for climate change, water resources, crops and public health at a regional and global level (Ramanathan & Xu, 2010; UNEP and C<sup>4</sup>, 2002)
  - Indo-Gangetic Plain in South Asia has been identified as one among five regional ABC hotspots world-wide (Ramanathan et al., 2008)

Results: We estimated that, for PM<sub>2.5</sub> and ozone, respectively, fully implementing these measures could reduce global population-weighted average surface concentrations by 23–34% and 7–17% and avoid 0.6–4.4 and 0.04–0.52 million annual premature deaths globally in 2030. More than 80% of the health benefits are estimated to occur in Asia. We estimated that BC mitigation measures would achieve approximately 98% of the deaths that would be avoided if all BC and methane mitigation measures were implemented, due to reduced BC and associated reductions of nonmethane ozone precursor and organic carbon emissions as well as stronger m... uncertainty, these est... concentration-respon...



“Black carbon is found worldwide, but its presence and impact are particularly strong in Asia.”

Source: NASA, 2009



# BC EMISSION: POLITICAL-ECONOMY PERSPECTIVE

- BC is a short-lived climate pollutant (SLCPs)
- Mostly local and regional and hence mitigating it can give quick results (Wallack & Ramanathan, 2009)
- Tide over the **free-rider problem** associated with climate change in general, wherein benefits of **mitigation are global and distant**, whereas **costs are local and immediate** (Gollier and Tirole, 2015)

Image source: Bruce et al., 2014



# DIESEL IRRIGATION IN THE INDO-GANGETIC PLAIN

- It is estimated that in the Indo-Gangetic Plain alone, over **ten million diesel pumps** operate
- Indo-Gangetic Plain:
  - Bangladesh
  - Indian states of Assam, Bihar, Haryana, Jharkhand, Punjab, Uttar Pradesh and West Bengal
  - Nepal
  - Pakistan
- This number has been increasing over time

## Diesel pumps in IGP around 1993




### Legend

 Indu\_Ganges basin


### Pakistan

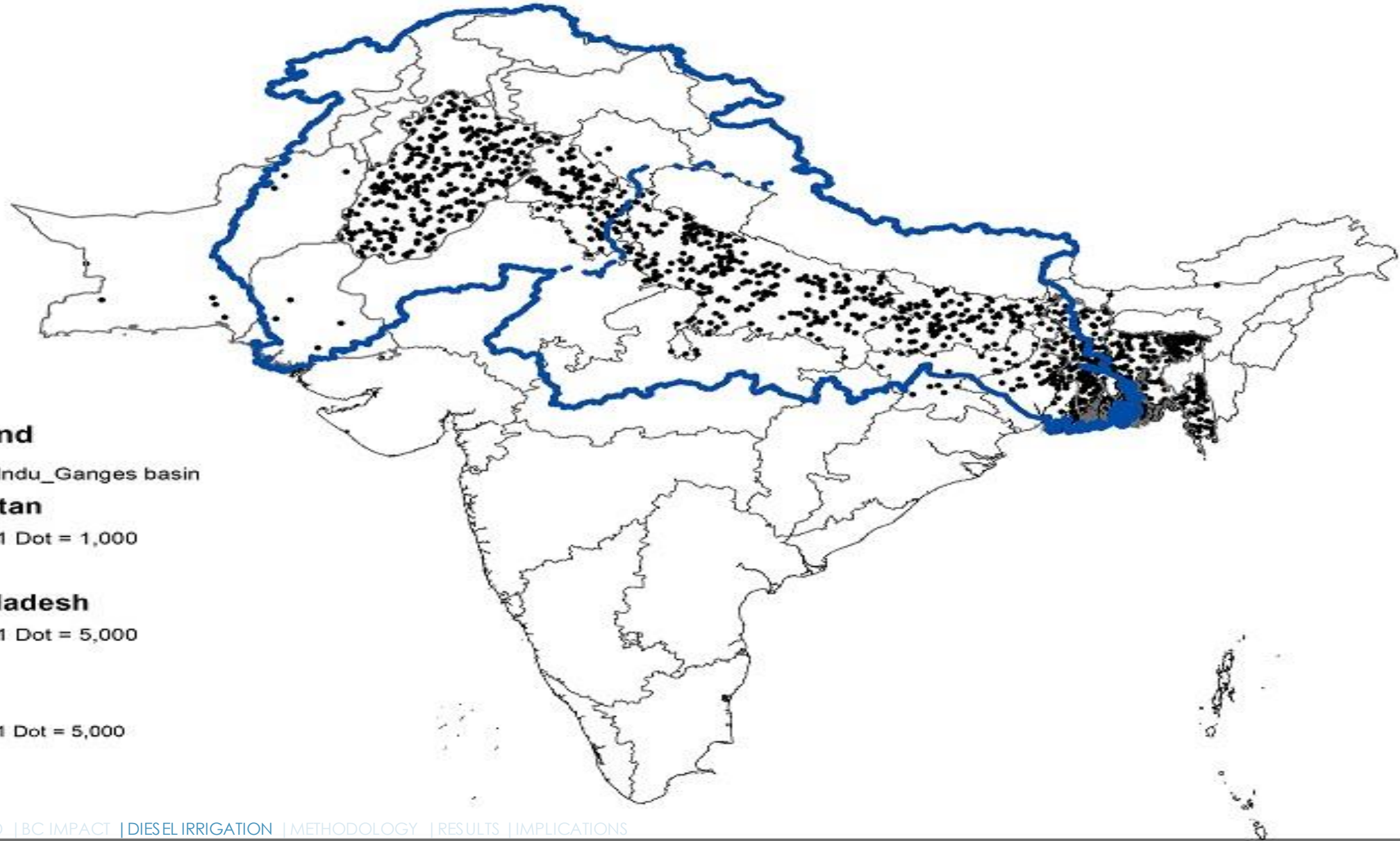
 1 Dot = 1,000

### Bangladesh

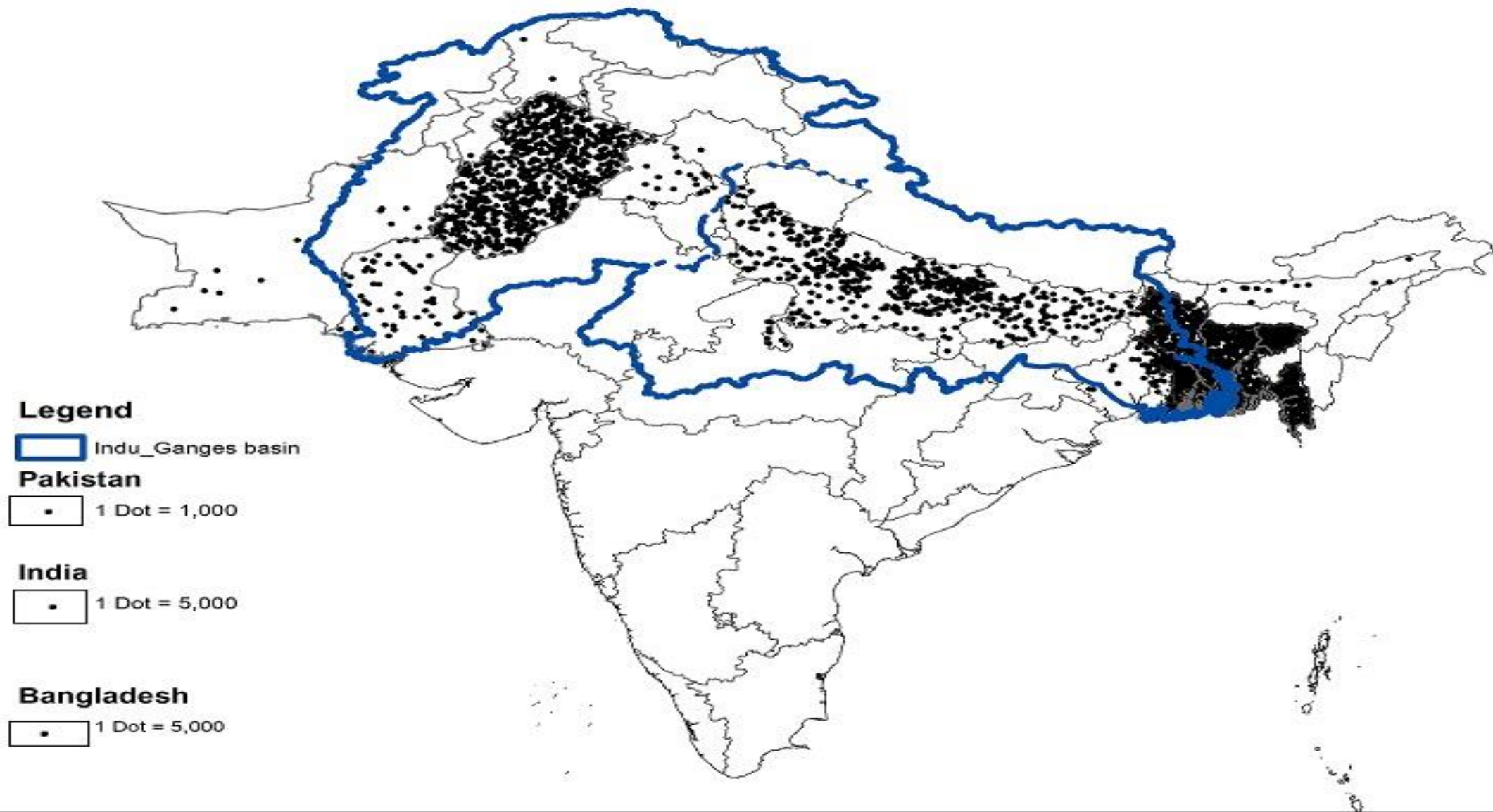
 1 Dot = 5,000

### India

 1 Dot = 5,000



## Diesel pumps in IGP around 2012/13



# ESTIMATING BC EMISSIONS FROM DIESEL IRRIGATION IN THE IGP: METHODOLOGY

$$E = N \times t \times EF \times L$$

'E' are BC emissions from the operation of diesel irrigation pumps

N: Number of diesel pumps

T: Hours of annual pump operation

EF: Emission factor (in g /L of diesel)

L: Diesel consumed in an hour by an individual pump (in L)



# UNIQUENESS



- Focus on the entire IGP region and not just a single country
- Study an overlooked source (diesel irrigation)
- Use an emission factor from the region that is based on actual measurement
- Analyse temporal changes
- Assume different efficiencies of the diesel pumps (reflected in diesel consumed)

## RESULTS

- Between the late **1980s to 2013-14**, annual BC emissions in the IGP from diesel irrigation pumps, **more than quadrupled**
- Black carbon emissions from diesel irrigation pumps for the latest available time period:
  - Bangladesh: 3 to 6.1 Gg (in 2013-14)
  - Pakistan: 2.5 to 4.9 Gg (in 2011-12)
  - Indian IGP states: 6.1 to 12.4 Gg (in 2013-14)
  - Nepal: ~0.5 Gg (in 2008-09)



# RESULTS

Our estimates for diesel irrigation pumps benchmarked against the relevant inventory's national estimates

Inventory referenced	Bangladesh	India	Nepal	Pakistan
Paliwal et al. (2016)		0.6%-1.7% [2011]		
Sadavarte et al. (2019) <sup>a</sup>				
Ohara et al. (2007)	2.6%-5.3% [2000]	0.8%-1.7% [2000]	0.6%-1.2% [2000]	1.3%-2.6% [2000]
Streets et al. (2003)	3.4%-6.8% [2000]	1.1%-2.2% [2000]	0.8%-1.6% [2000]	1.7%-3.4% [2000]
Dickerson et al. (2002)	4.1%-8.7% [2000]	0.8%-2.6% [2000]	0.9%-1.9% [2000]	1.4%-3.6% [2000]
Reddy and Venkataraman (2002)		5.6%-11.2% [2000]		

# ROUGH BENCHMARKING AGAINST NATIONAL BC EMISSIONS

Diesel irrigation pumps in the IGP comprise

- **5.5%** of **Bangladesh's** national black carbon emissions
- **1.2%** of **Nepal's** national black carbon emissions
- **2.5%** of **Pakistan's** national black carbon emissions
- **5.9%** of **India's** national black carbon emissions

# IMPLICATIONS

1. Substantial size of these emissions presents an opportunity for taking action towards sustainability that is in alignment with concerns of **food security** and **health**
2. While some reductions in BC emissions can accrue from more efficient diesel pumps, **significant reductions in BC can accrue from replacing diesel with a non-polluting source of energy**
3. Use of renewables to power irrigation pumps can serve as a catalyst towards the provision of renewable electricity in rural areas  
This in turn can
  - help increase employment opportunities (via targeted skilling programmes related to renewables)
  - help sustain growth
  - promote a convergence of living standards between urban and rural areas (Fennell et al., 2018)



2 ZERO HUNGER



7 AFFORDABLE AND CLEAN ENERGY



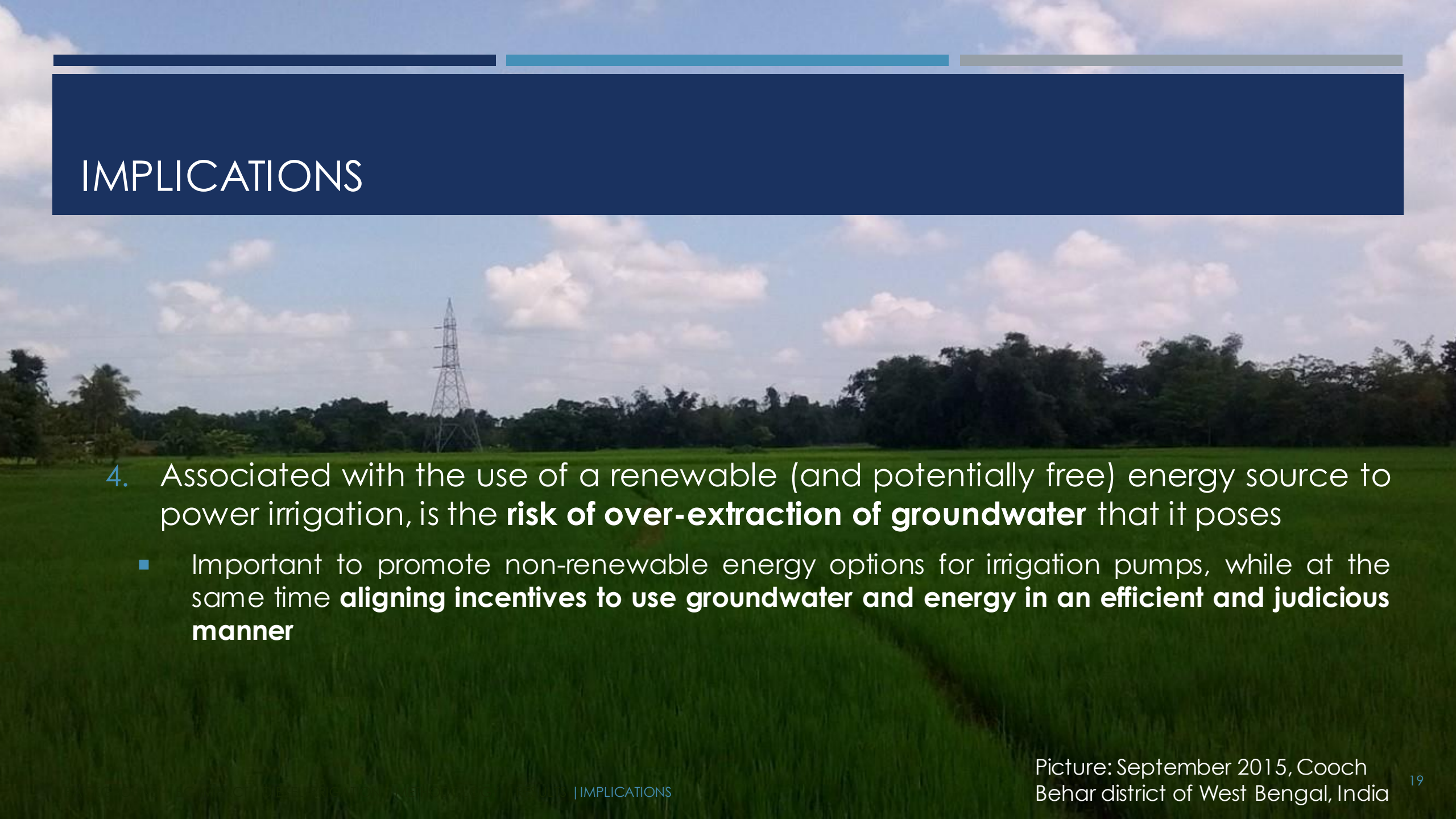
13 CLIMATE ACTION



3 GOOD HEALTH AND WELL-BEING



# IMPLICATIONS

- 
4. Associated with the use of a renewable (and potentially free) energy source to power irrigation, is the **risk of over-extraction of groundwater** that it poses
    - Important to promote non-renewable energy options for irrigation pumps, while at the same time **aligning incentives to use groundwater and energy in an efficient and judicious manner**

THANK YOU FOR YOUR ATTENTION