Methane and Health

Dialogue Series

April 11, 26 and May 10, 2023

Summary report prepared by RESOLVE

Environmental Defense Fund

The climate crisis is also a public health crisis, and methane, due to its impact on warming and air quality, threatens human health. Cutting methane is the quickest, most effective way to address climate change while delivering significant near-term health benefits.

Solutions exist today to help cut methane emissions. Identifying and quantifying the health benefits from methane reductions can support countries, communities and companies as they take action. Environmental Defense Fund convened a series of dialogues to discuss opportunities to advance methane mitigation strategies that improve health in the three major methane-emitting sectors—agriculture, oil and gas and waste. This report is a summary of those discussions.

About Environmental Defense Fund

One of the world's leading international nonprofit organizations, Environmental Defense Fund (edf.org) creates transformational solutions to the most serious environmental problems. To do so, EDF links science, economics, law, and innovative private-sector partnerships. With more than 3 million members and offices in the United States, China, Mexico, Indonesia and the European Union, EDF's scientists, economists, attorneys and policy experts are working in 28 countries to turn our solutions into action.

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Introduction

Between April 11 and May 10, 2023, Environmental Defense Fund (EDF) hosted a series of dialogues that brought together experts on oil and gas, agriculture, waste and public health to identify near-term opportunities to reduce methane emissions and improve human health. The dialogue series built upon discussions held by EDF at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 27 in Sharm-El-Sheikh, Egypt, about the nexus between methane and health, and upon growing global recognition of the importance of rapidly reducing methane emissions to combat climate change.

A highly potent greenhouse gas, methane traps over 80 times more heat in the atmosphere than carbon dioxide (CO_2) over a 20-year period; methane emissions account for roughly a quarter of current planetary warming (IPCC, 2013; Ocko et al., 2018). As methane is a more short-lived greenhouse gas than carbon dioxide, its warming impacts are felt for a matter of decades, as opposed to centuries in the case of CO_2 (International Energy Agency, 2022). As a result, methane mitigation is the quickest and most effective means to address climate change today.

Methane mitigation is the quickest and most effective means to address climate change today.

By 2030, the vast majority of methane emissions will come from the agriculture, oil and gas, and waste sectors, with approximately 40% of global methane emitted by the agriculture sector, 26% emitted by the oil and gas sector, and 20% emitted from the waste sector (Ocko et al., 2021).

Methane emissions contribute to climate-related threats like more intense and frequent extreme weather events (e.g., record heat and flooding), increased food insecurity, greater infectious-disease risk, reduced access to clean water and deteriorating air quality. Beyond undermining public health as a short-lived climate pollutant, methane (and co-emitted pollutants) impacts health by contributing to ground-level ozone and particulate pollution that causes and exacerbates respiratory and cardiovascular diseases, cancer and stroke. The Global Methane Assessment focuses on the health impacts related to heat and ozone, calculating that the expected 0.3°C decrease in global warming from cutting methane emissions is expected to prevent 255,000 premature deaths and 775,000 asthma-related hospital visits per year by 2040.

EDF's dialogue series sought to identify methane emissions mitigation strategies that maximize these health benefits. While the risks posed by ozone and heat are significant, the dialogue series focused on the specific sectoral interventions needed to reduce methane and associated co-emissions from energy infrastructure, agriculture and landfills, where there is an urgent need to evaluate and characterize other significant and more localized health benefits of emissions mitigation. Doing so can provide a more robust understanding of the benefits and costs of the intervention; inform more targeted policies that support community health and economic development needs; and expand public support for the actions and investments required to meet and expand methane reduction commitments.

By 2030

40%

of global man-made methane emissions are projected to be from the **agriculture** sector

26%

are projected to be from the **oil and gas** sector

20%

are projected to be from the **waste** sector

For example, the location of oil and gas production in proximity to communities raises significant health concerns. The large volume of flared gas with relatively low combustion efficiency can be a source of volatile organic compounds such as benzene, polycyclic aromatic hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides and soot, in addition to methane emissions.

For all three of these sectors, proven mitigation strategies exist that, if implemented, could reduce methane emissions by as much as 55% overall by 2030 (Ocko et al., 2021). Achieving this mitigation potential is a complex task, with mitigation approaches, regional variations and cultural sensitivities that are highly specific to each sector. Each sector also has its own distinct health impacts, leading to diverging approaches to mitigating these health hazards alongside methane emissions.

To address this challenge, EDF's dialogue series brought together experts in each of these three sectors to collaboratively identify the most promising opportunities for near-term action within each sector that reduce methane emissions and benefit health. This shared understanding will help identify and prioritize policy-relevant research needs and build support for investment in methane mitigation activities that secure health, climate and economic benefits. Focusing the methane research agenda on characterizing health consequences of methane mitigation strategies will be critical in achieving the economy-wide Global Methane Pledge goals. In many cases there are known methane reduction interventions with existing technologies and best practices. The challenge for the world is how to accelerate durable solutions that incorporate a focus on improving the health of local communities.

Dialogue participants came together from across the globe, including China, Ghana, India, Italy, Malaysia, Mexico, Tanzania, the United Kingdom, and the United States. They contributed their expertise to three virtual sessions on April 11, April 26, and May 10, 2023, hearing from experts on the nexus of methane and health and working in focused sectoral breakout sessions to identify global opportunities for action based on their varied academic, professional and regional perspectives. The series concluded with a planning session focused on leveraging the road to COP 28 and other international dialogues to raise the profile of the health benefits of methane mitigation, and spur momentum for rapid action. A list of participants is included in Appendix A.

This report summarizes insights from each of the three sectoral discussions, as well as key near-term actions identified by the entire group of participants. The group did not seek to achieve consensus on any specific recommendations, interventions, advocacy or policy positions. As such this report is a summation of the individual contributions of all participants and should not be read as an enforcement of any specific action.

About

31%

of global methane emissions will come from **livestock** by 2030

Agriculture Sector

Status of the Sector

The agriculture sector is projected to produce approximately 40% of total global methane emissions in 2030, including about 31% from livestock, 8% from rice farming and 1% from the burning of agricultural waste (Ocko et al., 2021). Discussion during the dialogue series focused largely on livestock, which produce methane via enteric fermentation during the digestive process and via anaerobic decomposition of manure. By contributing to overall greenhouse gas emissions, livestock methane emissions exacerbate the impacts of climate change on human and animal health. These health threats, including increasing exposure to vector-borne diseases and causing more frequent natural disasters and extreme heat events, can directly affect livestock systems, thus reducing nutritional output for human consumption, increasing prevalence of animal diseases and zoonotic disease exposure for farmers and their families, and threatening farm financial viability.

In much of the world, livestock are an essential source of nutrient-dense food, livelihoods and socio-cultural stability. Livestock farming encompasses a wide range of settings, including smallholder farmers in the Global South, livestock producers in inarable lands of the Global North (e.g. Western UK, Iceland, etc) and high-efficiency livestock systems in developed countries, mainly in the Global North. Depending on the context, livestock farming has a variable contribution to methane emissions and is negatively impacted by climate change by varying degrees.

Acknowledging the variation of farming practices around the world, the group focused on opportunities to better manage livestock in all settings, such as optimizing livestock productivity through strategies that improve animal health, animal nutrition and animal adaptation and resilience. These actions have the potential to create benefits for human health and to reduce methane emissions. Specifically, healthier livestock that produce greater quantities and more nutritious milk and meat support human health by improving food security, reducing health burdens, providing more secure livelihoods and achieving sustainability goals. Improved productivity also reduces the methane emissions intensity of the sector by decreasing the methane emissions produced per unit of milk or meat produced and per unit of land utilized and can reduce the absolute methane emissions compared to business as usual. Therefore, the focus of the group centered around identifying solutions that benefit farmers, their communities and the environment.

Pathways for impact on human health and methane mitigation

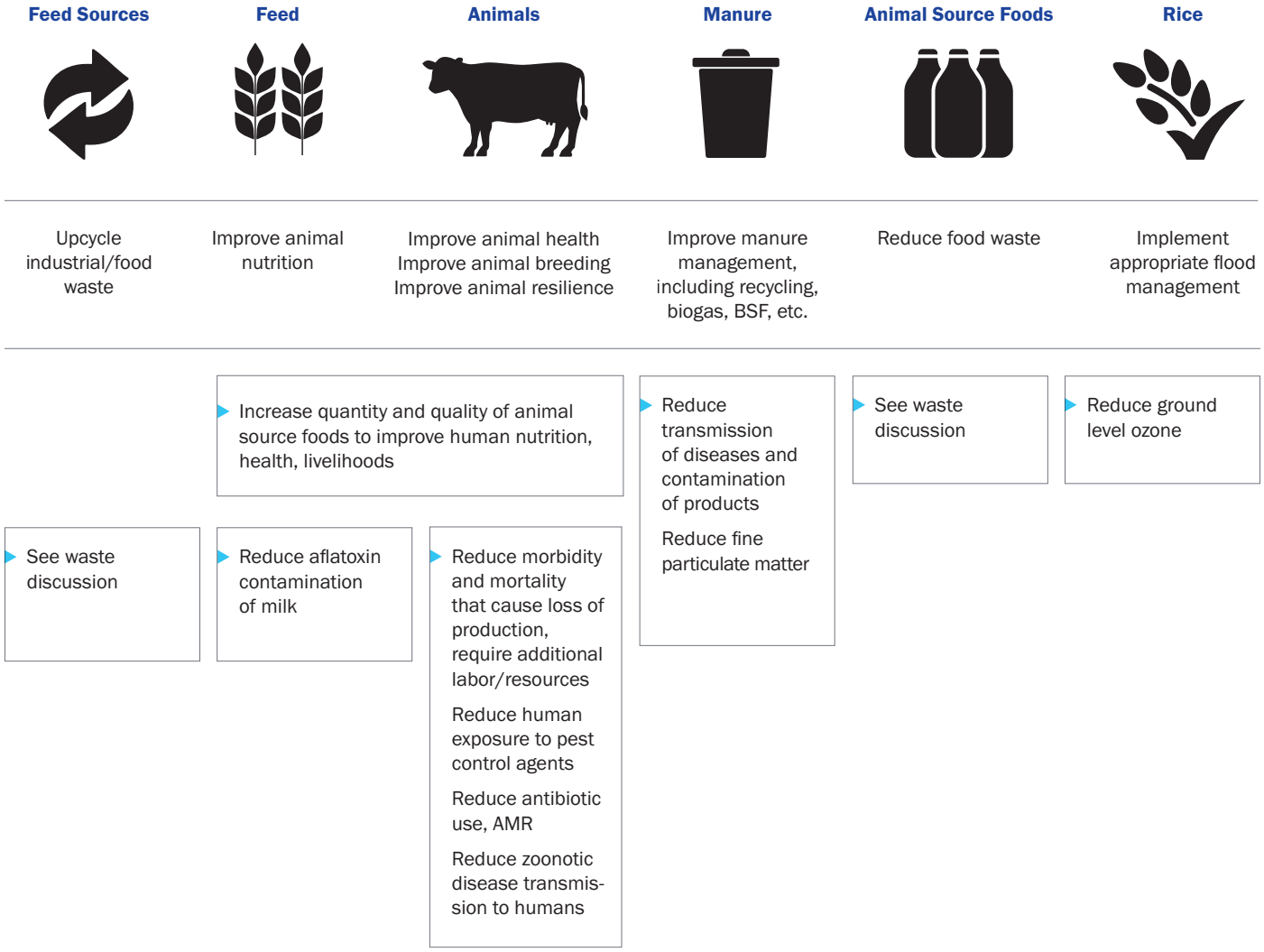


FIGURE 1: A chart showing the potential pathways to improve human health through productivity improvements in the livestock industry, which would decrease the methane intensity of the sector.

CASE STUDY

Vaccination and Veterinary Services Provision in the Sahel

One possible strategy is exemplified by the World Bank's PRAPS 2 project (Projet regional d'appui au pastoralisme au Sahel – Phase 2), currently underway in the Sahel region. Among other initiatives, PRAPS 2 supports expanded vaccine availability and administration and increased access to veterinary services for pastoralists. The Food and Agriculture Organization of the United Nations (FAO) found that these measures increased productivity by 17% while reducing overall methane emissions by 1.5%. Information about this project was presented to dialogue participants by Dr. Anne Mottet, Livestock Development Officer at FAO at the time of the presentation, now Lead Technical Specialist, Livestock at the International Fund for Agricultural Development (IFAD).

Key Topics of Debate and Discussion

During the dialogues, participants from a wide variety of disciplines and backgrounds worked together to build a shared understanding of how productivity optimization can be leveraged to benefit human health and reduce methane emissions. Key topics of debate and discussion from the agriculture sector breakout group are summarized below.

Improvement in animal health can reduce zoonotic diseases that currently comprise 75% of all emerging infectious diseases in humans.

- **Importance of animal health and welfare:** Participants agreed on the importance of animal health and welfare. This entails optimizing inputs such as diet, reproduction and husbandry to maximize production efficiencies and strategies for mitigation of both enteric and manure management sources of methane. Importantly, these goals need to be aligned with human dietary needs and socio-cultural values of farming. Improvement in animal health can also reduce zoonotic diseases that currently comprise 75% of all emerging infectious diseases in humans.

  While the benefits of improved animal health for optimized productivity are empirically demonstrated, data quantifying the impact of animal health on human health outcomes and methane emissions are lacking. In terms of livestock nutrition, poor or insufficient feeds, limited nutritional diversity, and other challenges lead to malnourished animals and diminished animal health and also reduce the resulting nutritional value of animal-sourced foods for human consumers. However, there is limited data on these linkages, because few human nutritionists collaborate with animal scientists, making it difficult to quantify how improved practices benefit human health.

- **Methane emissions quantification in livestock:** Quantification of changes in methane emissions in the livestock context is often dependent on proxy variables or markers such as efficiency of production or milk fatty acid analysis. However, the data used to create these proxies comes from the Global North, where breeds, farming practices and many other factors are distinct from the Global South. There is also ongoing research to more completely understand the cattle microbiome and methane production in the cattle rumen, and the genetic and environmental factors that contribute to methanogenesis. Participants were divided on whether improving this understanding should be a short- or long-term priority to support implementation of beneficial practices. An innovation system comprised of flexible participatory field research will be necessary to strive for near-term advancements in methane mitigation.

- **Food systems approach:** Participants also suggested that solutions should look beyond the livestock sector to develop more integrated solutions through a "circular food systems approach." For example, feeding food waste to livestock can reduce landfill methane emissions, reduce feed costs and spare land and fertilizer usually used to grow cattle feed, in addition to potential benefits for improved animal productivity and absolute enteric methane emissions reductions.
- **Policy levers:** Participants agreed that governments and other actors should create robust and long-term (multi-year) incentives for farmers to implement these changes. Depending on the context, different policy levers will be necessary, as animals play very distinct roles in socioeconomic life across different regions. In many cases, extension services will play a key role in introducing new practices to farmers and supporting implementation, with the goal of increasing knowledge of practices that reduce methane emissions and other pollutants.
- **Rice:** Participants briefly discussed options for reducing methane emissions from rice farming, including changing practices such as the timing and regularity of flooding rice fields. While reducing methane emissions from rice farming is important, it was not the primary focus of this dialogue series due to its relatively small contribution to overall methane emissions and the expertise of the participants.

Through these discussions, participants developed a comprehensive understanding of potential strategies for optimizing productivity with benefits for human health. This information was captured in a table which can be found in Appendix C.

Feeding food waste to livestock can reduce landfill methane emissions, reduce feed costs and spare land and fertilizer usually used to grow cattle feed.

Opportunities to Reduce Methane Emissions and Benefit Human Health

Following two sector-specific breakout sessions, participants in the agriculture sector breakout group shared strategies they had identified with the larger group. These opportunities are summarized here; further information can be found in Appendix B.

- **Improved animal nutrition** can increase the quantity and quality of animal-sourced foods and reduce aflatoxin contamination of milk to improve human nutrition, health and livelihoods.
- **Improved animal health**, breeding and resilience can reduce animal morbidity and mortality, preventing production losses and the need for replacement animals and limiting the need for additional human labor and resources; reduce human exposure to zoonotic diseases and vector-borne agents; reduce antimicrobial use; and increase the quantity and quality of animal-sourced foods to improve human nutrition, health and livelihoods.
- **Improved manure management** can reduce disease transmission and product contamination, enhance access to fertilizers for crop production and soil enhancements, and reduce methane co-pollutant gases and fine particulate matter that pose a public health hazard to local communities.
- **Reduced waste of animal source foods** can increase the availability of animal sourced-foods for human consumption.
- **Implementation of appropriate flood management in rice farming** can reduce the formation of ground-level ozone.

Implementing these strategies will require development of extension programs that can train farmers in new techniques and provide technical support and the creation of incentive structures for farmers to participate in trials and ultimately, implement these practices. For animal health improvements to be made, access to vaccines, veterinary care and disease surveillance and control must be expanded. Workforce shortages in large animal veterinary medicine pose an additional challenge that will necessitate workforce development of both veterinary professionals and paraprofessionals.

Research will be needed to quantify the effects of productivity optimization on both human health and methane emissions and develop markers and models for livestock methane emissions under various scenarios. Research will also be necessary to improve our understanding of the cattle microbiome, metabolism and methane production, with the goal of developing interventions that can reduce methane production. Breeding and husbandry (e.g. housing) strategies should also be explored that can support livestock's resilience to climate change in various regions in addition to methane mitigation potential. Policies and infrastructure also need to be developed at the regional and national levels to promote best practices and support adoption by farmers.

26%

of global methane emissions will be produced by **oil and gas** by 2030

Oil and Gas Sector

Status of the Sector

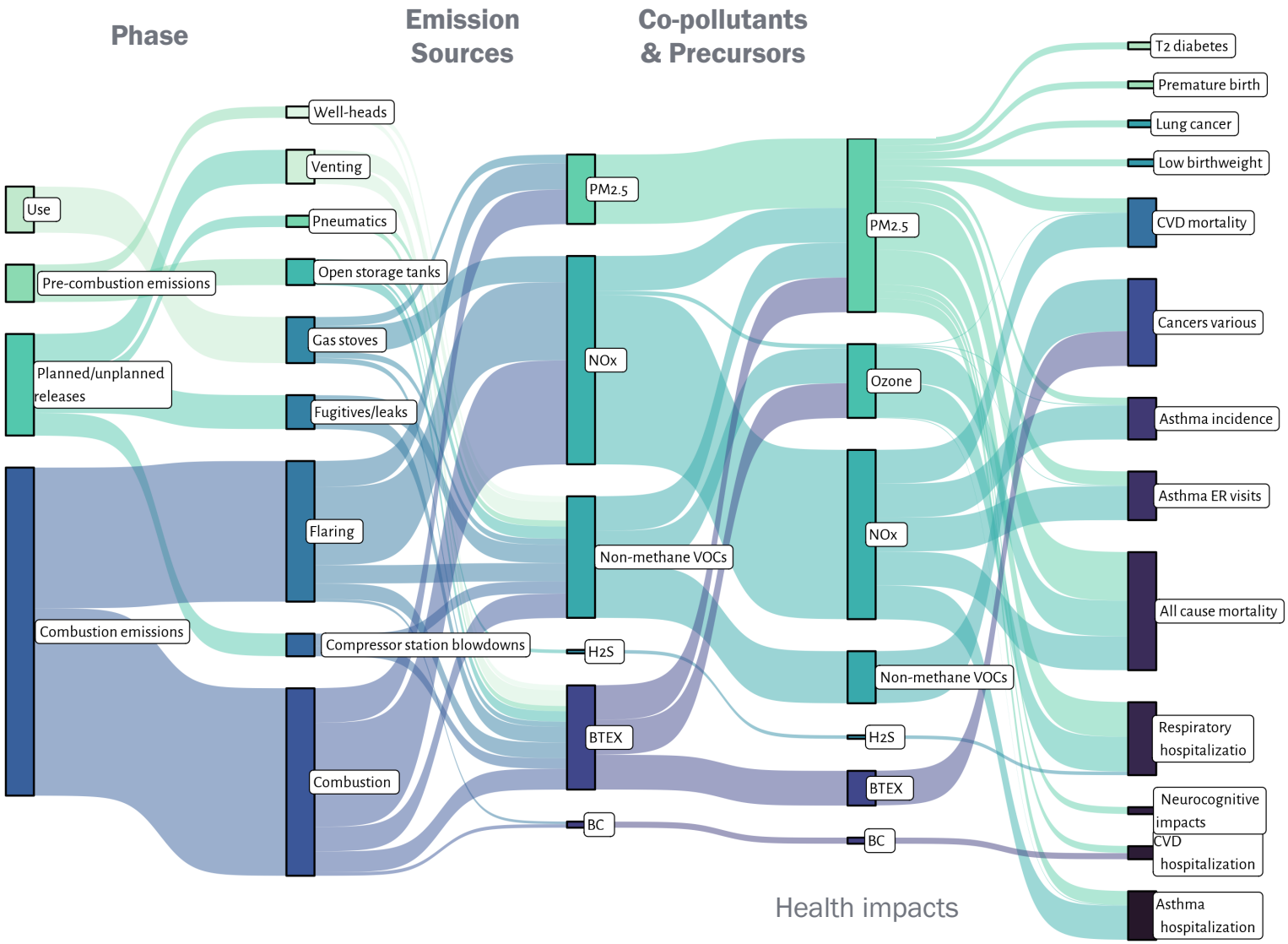
Methane is released throughout the oil and gas supply chain, from extraction (upstream), transport and storage (midstream), and residential or industrial use (downstream). In total, the sector will account for 26% of global methane emissions by 2030 (Ocko et al., 2021). Some of these emissions are unplanned, such as fugitive emissions and leaks from onsite equipment such as pneumatic pumps that inject chemicals into oil wells. In other cases, particularly on sites where oil is the primary commodity being extracted, methane is emitted as part of normal operations. Methane is often vented from open storage tanks, releasing co-pollutants such as VOCs and BTEX (benzene, toluene, ethylbenzene and xylene). Some producers use flares to burn methane gas, releasing co-pollutants such as NO_X and $PM_{2.5}$. Each of these co-pollutants can have negative impacts on human health.

The majority of methane emissions sources in the oil and gas industry can be reduced using existing technologies and best practices at minimal net cost (Ocko et al., 2021). However, breakout group discussion identified that current regulatory frameworks have not been able to address these emissions or incentivize action to reduce them. Accounting for the health benefits of methane emissions reduction could enhance policy and regulatory efforts, but methane emitting practices in this industry affect human health through complex pathways of exposure that must be quantified to support these efforts.

Participants in the oil and gas sector breakout group from different disciplinary and regional contexts worked together to create a map of these exposure pathways, that served as a foundation for their efforts to prioritize the methane reduction actions with greatest potential benefits to human health.

Assessing methane emitting activity health impacts: a focus on air pollution

Height identifies the frequency of sources identified during breakout sessions and does not reflect strength of association



*=co-pollutant & precursor

FIGURE 2: An alluvial chart showing the co-pollutants and precursors that emerge from specific sources within the Oil and Gas value chain and their interactions and subsequent impacts upon human health.

CASE STUDY

Quantifying Health Impacts of Air Pollution from Oil and Gas Extraction

Efforts to quantify the health impacts of methane-emitting practices in the oil and gas industry are supported by consistent improvements in data collection and modelling capabilities. One analysis presented by Dr. Jonathan Buonocore, Boston University, modeled the health impacts of air pollution from oil and gas extraction in the United States and showed that the sector accounts for 7,500 premature deaths, 2,200 new asthma cases and $77 billion in health damages annually." (Buonocore et al., 2023). Most quantifiable impacts were driven by the co-pollutant NO_x, which is mainly released from onsite combustion processes such as pump jack engines, compressor stations and flares.

Key Topics of Debate and Discussion

Participants worked together to build a shared understanding of the challenges and opportunities related to methane emissions reduction and quantification of resulting health benefits in the oil and gas sector. Key points of discussion from the oil and gas sector breakout group are summarized below.

- **Methane emissions inventory and quantification:** While existing regulations in oil-producing countries such as the United States and Mexico place limits on emissions of methane and its co-pollutants in the oil and gas industry, in many cases onsite inspections significantly underestimate emissions. This can be addressed by creating estimates using modeling data, but these models do not always account for differences across geological, regional and technological contexts. Initiatives such as EDF's forthcoming satellite measuring global methane, MethaneSAT, and others aim to fill in data gaps on the quantification and specific source location of methane emissions. Especially if satellite systems are paired with bottom-up equipment inventories or other measurement techniques that can determine source level emissions, they will transform the ability to accurately quantify emissions at the site level and to enforce compliance with emissions regulations.
- **Techniques for quantifying health impacts:** As an alternative to traditional exposure assessment, participants recommended using available data to calculate the probabilistic risk from exposure to a given health hazard in a certain population or region. This can be done using data inputs that are more readily available.
- **Accounting for regional differences in exposures and impacts:** Participants noted that the effects of methane emissions from the oil and gas industry vary widely across regions and across urban and rural contexts. In particular, communities that are dependent upon natural resources for their livelihoods, such as agriculture and forestry, may suffer from the loss of ecosystem services due to ozone pollution in ways that current models do not account for. In addition, the ratio of methane emissions to co-pollutants varies widely depending on region, source and process, making modeling health impacts from co-pollutants at a broad scale challenging.

- **Applying new data sources:** Participants discussed the potential to apply new data sources that will soon become available, including satellite data from initiatives such as MethaneSAT, global mapping of the locations of fossil fuel infrastructure, and co-pollutant inventories seeking to estimate the co-pollutant composition of different methane sources.
- **Coal mining:** Participants touched on the significant quantity of methane that is emitted from coal mines. While mitigating these emissions is important, it was not a primary focus of breakout session discussion.
- **Approaches to mitigation:** Strategies to mitigate emissions of methane and co-pollutants can follow two approaches. One approach is to control the release of specific chemicals in engineering terms during the extraction and production process. Another approach is to look at control more holistically and seek to reduce production. These more holistic approaches could include pushback against construction of new fossil fuel infrastructure, to prevent "locking-in" future emissions. These strategies are not mutually exclusive, but rather can be deployed in a complimentary manner according to the context of each emissions source, so that the maximum emissions reduction can be achieved.
- **Empowering communities to participate in decision-making:** Participants emphasized the importance of sharing data with communities near fossil fuel infrastructure, learning from their lived experiences and working with them to develop solutions. As one participant noted, "Carbon neutral is not health neutral." Even if greenhouse gas emissions are balanced out by carbon sequestration, the local health impacts of fossil fuel infrastructure are not erased.

Through these discussions, participants developed a comprehensive understanding of potential strategies for methane emissions reductions with benefits for human health. This information was captured in a table which can be found in Appendix C.

Even if greenhouse gas emissions are balanced out by carbon sequestration, the onsite health impacts of fossil fuel infrastructure are not erased.

Opportunities to Reduce Methane Emissions and Benefit Human Health

Following two sector-specific breakout sessions, participants in the oil and gas sector breakout group shared strategies they had identified with the larger group. These opportunities are summarized here; further information can be found in Appendix B.

- **Apply existing industry best practices:** Producers should update onsite equipment to conform with existing industry best practices, such as electrifying compressors and other onsite sources of combustion and improving flares to burn methane more efficiently and cleanly, to avoid releasing harmful co-pollutants such as NO_x. Producers should also improve and replace seals on compressors, tanks and wells to prevent fugitive methane emissions.
- **Re-engineering:** Producers should make engineering changes to production sites to enable them to capture, transport, and sell methane produced as a byproduct of oil drilling, rather than venting or flaring it. This is doable at no net costs using revenues from selling methane as natural gas.
- **Improve monitoring:** On a site level, leak detection and repair (LDAR) monitoring is needed around site boundaries, to detect methane leaks and releases of other co-pollutants more accurately. The accuracy of existing onsite monitoring should be validated based on satellite monitoring data and divergences should be investigated.
- **Engage the public:** Collaborate with communities affected by these health hazards. This should include sharing data with communities about their exposure risks, and importantly, partnering with them to develop and prioritize solutions based on their concerns, experiences and expertise. New satellite data, air pollution modeling and other data sources can also be shared with impacted communities and local advocates, who can use the data to validate their experiences living with pollution.

The impacts of methane emissions from the oil and gas industry travel across regional and national boundaries, requiring a unified approach to regulating air pollution.

In the near term, participants suggested that implementation of these strategies will require regulations to be updated to leverage new, more powerful monitoring technologies. For example, the Inflation Reduction Act (IRA) in the United States includes a methane fee that requires estimates of methane emissions to be "empirical and accurate" based on new data. The availability of this data could also lead to modifications in how emissions inventories are structured. Participants also proposed that regulators, civil society and other sectors take a holistic, "life-cycle" approach to achieving methane emissions reduction. One suggested strategy is to differentiate fossil fuel on the market by calculating its "methane intensity" over its lifecycle in order to influence demand.

In the long term, challenges to quantification and regulation of emissions will need to be addressed to effectively limit methane emissions and reduce their health effects. On the quantitative side, the spatial resolution of emissions inventories resolutions may still be too coarse (e.g. county-level) to pinpoint and address specific sources. There is also no consistent ratio between methane and co-pollutants, making it very challenging to quantify and model health impacts without data on specific source compositions.

Regional differences also pose challenges. On the regulatory side, the impacts of methane emissions from the oil and gas industry travel across regional and national boundaries, requiring a unified approach to regulating air pollution. Finally, health concerns in regions where most drilling is conducted offshore, such as Southeast Asia, need more in-depth exploration to better understand differences in health priorities.

Waste Sector

Status of the Sector

The waste sector will be responsible for 20% of global methane emissions by 2030, with 14% emitted from landfills and 6% emitted from wastewater (Ocko et al., 2021). Methane emissions from solid waste disposal and wastewater systems are largely produced by the anaerobic decomposition of organic matter, including anaerobic decomposition of human waste. $PM_{2.5}$ is emitted during combustion of waste (e.g. incineration facilities, open burning of waste, landfill fires) which can also negatively impact respiratory and cardiovascular health. Waste management systems vary widely by region, and in many parts of the world waste is untreated and can contribute to the spread of vector borne diseases or enter water sources and spread pathogens. In addition, many communities living nearby solid and liquid waste disposal sites are affected by odors and other related quality of life issues.

By 2030,

14%

of methane will be emitted from **landfills**

6%

will be emitted from **wastewater**

Improving waste management practices to reduce methane emissions provides a major opportunity to reduce the waste sector's current impacts on human health. Many interventions to reduce methane emissions from waste are being developed and implemented. Participants in the waste sector breakout group worked together to identify and prioritize the interventions that maximize methane emissions reduction and human health benefits across the stages of waste disposal, processing and treatment.

Health benefit opportunities across waste management strategies for methane mitigation

1. Source reduction	2. Processing approach/technology	3. End-stage treatment
▶ Reduce food waste	▶ Composting	▶ Biogas collection for energy
▶ Point source segregation	▶ Non-sewered to sewered system	▶ Leachate/fly ash treatment/recovery
▶ Packaging reduction	▶ Landfill/WWTP design: e.g., covers, biocovers; methanotrophic bioaugmentation	▶ Installation of flares at WWTP/landfills
	▶ Landfill fire prevention	▶ Incineration toenergy/heating

Health benefit opportunities across waste management strategies for methane mitigation

Diarrheal disease caused by water-borne pathogens, helminths

PM and ozone related premature mortality, asthma, cardiovascular/pulmonary disease

Vector-borne diseases (reductions in rodent, fly, mosquito habitat)Mental health/well-being from odor reduction

Cancer, neurodevelopmental, reproductive from water/air/soil contamination by dioxins, metals

Malnutrition, child stunting

Occupational injuries (informal recycling)

Climate-related (e.g. heat-related mortality and morbidity, flood-related, vector-borne)

FIGURE 1: Diagram illustrating a framework for health benefit and methane mitigation opportunities across waste management stages, developed by the Waste Sector breakout group

CASE STUDY

Diversion of Human Waste from Pit Latrines

Currently 1.8 billion people use pit latrines for sanitation, which are a major source of global methane emissions, estimated to be between 3.8 – 4 terragrams of methane per year (Tg CH4y-1) or approximately 1% of anthropogenic methane emissions (Reid, 2014). Participants learned about programs to divert human waste from pit latrines to composting facilities; the products of this process can then be used in agricultural processes. Diverting human waste from pit latrines can both reduce methane emissions and improve human health, as illustrated by the Sustainable Organic Integrated Livelihoods (Haiti) and Regen Organics (Kenya) case studies.

Regen Organics uses container-based sanitation, or CBS, to divert human waste from pit latrines. The human waste is transported to processing facilities where it is combined with market and food waste. Black soldier fly larvae (BSFL) are reared on the composting waste and can then be sold as animal feed. The waste can be further composted and eventually sold as a fertilizer. Overall, this processing technique reduces CO_2-equivalent emissions of methane by 50% compared to thermophilic composting, and also improves water quality in communities dependent on pit latrines and addressing the critical need for fertilizer and protein-rich animal feed in low-income countries (Mertenat et al., 2019).

Reducing inputs into landfills by reducing food waste, segregating waste streams at the point of generation and reducing packaging can reduce overall methane emissions.

Key Topics of Debate and Discussion

Participants worked together to build a shared understanding of the challenges and opportunities related to reducing methane emissions and improving health through interventions in the waste sector. Key points of discussion from this process are summarized below.

- **Addressing variation in existing waste management systems:** Because there is so much variation in existing systems for managing both solid and liquid waste, solutions must be tailored to specific local and regional contexts. For example, managed landfills can install systems to capture and redirect methane or utilize biocovers or methanotrophic bacteria to reduce methane emissions, while interventions to reduce incineration of solid waste might be a priority in other areas. Equally, addressing emissions from pit latrines might be a priority in the areas where they are most widely used, while addressing leakages from sewer systems might be a priority in other regions.
- **Quantifying methane emissions and mitigation for small point sources:** Participants discussed the limitations of remote sensing capabilities for smaller sources of methane, such as latrine pits, and their implications for the ability to quantify methane emissions reductions due to proposed interventions. To identify a point source of emissions using remote sensing, a plume over time is needed, which may not be detectable in the case of these dispersed sources. Participants suggested other possible approaches such as identifying an enhancement or decrease in methane concentrations over a large area, or deploying ground based continuous sensors to measure ground concentrations.
- **Engaging communities in monitoring and accountability:** Participants suggested engaging communities near waste management sites in efforts to implement interventions, saying that their involvement can often encourage waste managers to go beyond what's required by regulations and address issues such as odors.
- **Potential for greater uptake of action based on "health angle":** Waste managers, regulators and policymakers may be more motivated to improve waste management practices based on their health benefits to communities than they are by arguments about greenhouse gas emissions.

Through these discussions, participants developed a comprehensive understanding of potential strategies for methane emissions reductions with benefits for human health. This information was captured in a table which can be found in Appendix C.

Opportunities to Reduce Methane Emissions and Benefit Human Health

Following two sector-specific breakout sessions, participants in the Waste sectoral group shared strategies they'd identified with the larger group. These opportunities are summarized here; further information can be found in Appendix B.

- **Source reductions:** Reducing inputs into landfills by reducing food waste, segregating waste streams at the point of generation and reducing packaging (among other measures) can reduce overall methane emissions of the sector. In addition, source reduction can also reduce vector-borne diseases and improve mental health and well-being from odor reduction. Reduced food waste could also potentially contribute to reduced malnutrition.
- **Processing approaches/technologies:** Changes in processing approaches can include fire prevention at landfills, redesigning landfills and wastewater treatment plants, composting both organic landfill waste and human waste, and transitioning from non-sewered to sewered systems where possible. Implementing these approaches can reduce water-borne diarrheal disease, vector borne diseases, odors and occupational injuries from informal waste management, as well as capturing and mitigating methane emissions.

- **End stage treatment:** At the end stage, waste managers can implement strategies such as collecting biogas for energy, installing highly efficient flares to burn biogas onsite, or incinerating organic waste for energy and heating, though the methane mitigation potential depends on the efficiency of these systems and the comparison point for each intervention. In addition to mitigating methane emissions, these measures can reduce premature mortality related to particulate matter and ozone.
- **Across stages:** Methane emissions reduction strategies in each stage could also potentially contribute to reductions in cancer, neurodevelopmental and reproductive diseases caused by dioxins and heavy metal contamination in the water, air and soil.

In the near term, participants raised the potential for carbon credit financing to support actions based on their methane mitigation potential. This would require the sanitation sector to have improved access to carbon markets, as well as methods for measuring emissions reductions. Participants also suggested calling attention to odor complaints from nearby communities as the primary driver for action and enforcement by waste managers and regulators. To realize the full potential of strategies such as source reduction, participants also proposed building coalitions with the agriculture and nutrition sector and developing a food systems approach to methane mitigation. Coalitions can also be built with environmental justice groups that are focused on combatting the health impacts of landfills and wastewater treatment plants.

In the long term, there is a need to build up a base of evidence to enable more accurate quantification of these strategies' benefits for methane mitigation and human health. Ground-level air and water quality sensor data over time need to be evaluated alongside odor complaints and documented methane reductions. Research is also needed to quantify diarrheal disease reductions from mitigation strategies applied to sewered and non-sewered wastewater treatment systems. Finally, community health benefits stemming from source reduction strategies need to be characterized, as well as the benefits of composting and other food systems strategies.

Opportunities to Leverage the Road to COP28

Following the sector-specific discussions, participants spent the final session of the dialogue developing strategies to advance their collective recommendations. COP 28, which will be held in Dubai in November-December 2023, is a major opportunity to build international understanding and momentum around methane mitigation's health benefits. At COP itself there will be a Health Day for the first time, as well as conversations about methane across many venues, providing a variety of opportunities to drive home key messages on methane and health. Participants discussed strategies to leverage these events, as well as other on-going global dialogues and platforms, to build momentum around recommended actions. Their contributions are captured in a table, included as Appendix D, and summarized here.

Critical Audiences

Participants identified a number of critical international audiences to be targeted with methane and health messaging. These audiences include donors/funders, international humanitarian organizations and policymakers; regulators, legal professionals, industry representatives and research organizations; and health professionals, educators and community based/civil society organizations. Each of these audiences can be targeted at high-level international convenings, as well as assemblies at the national and local scale. Participants emphasized that high-level engagement must be balanced with building local connections with community organizations and social influencers, so that action is supported from the ground up.

High-level engagement

must be balanced with building local connections with community organizations and social influencers, so that action is supported from **the ground up**.

Critical Messages and Information Needs

Participants also brainstormed the information each sector would need to make the case for action on methane mitigation.

- **Agriculture sector:** Participants noted the need for a clear explanation of the linkage between agriculture, methane and health, as well as for education about the short-term climate impacts of methane.
- **Oil and gas sector:** Participants similarly noted that informational materials that clearly link methane, its co-pollutants and resulting health impacts would be essential for making the case for action. They also suggested that the legal community could assist in building legal toolkits for communities who want to engage in the permitting and siting process for future oil and gas infrastructure projects.
- **Waste sector:** Participants said that a quantification of methane reductions and health benefits from proposed actions in the waste sector would be useful. This information could support the development of a broad-scale cost-benefit analysis of methane mitigation strategies across sectors that incorporates health impacts, possibly building on reports such as Abt's Societal Benefits of Methane Mitigation (Reading et al., 2022) which policymakers could use to make decisions.

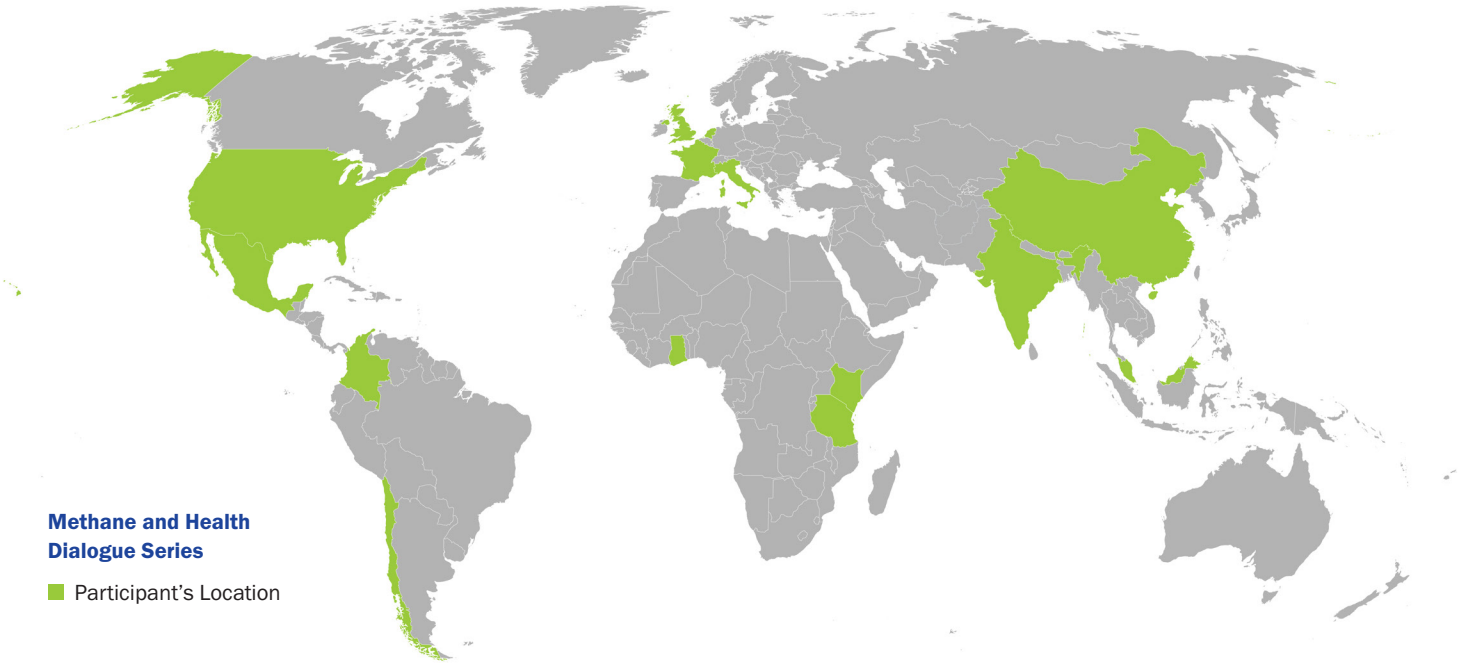
Conclusions

The sessions closed with expressions of gratitude from the EDF team members who organized the dialogue series, and from participants who appreciated the chance to learn from each other. Many participants also expressed interest in continuing to communicate and collaborate on these issues, and to support each other's efforts to mitigate methane emissions to the benefit of human health.

APPENDIX A

Dialogue Participants

Participants attended Methane and Health Dialogue Series from around the world, bringing their diverse expertise to bear and considering how to apply promising strategies across a wide variety of social, economic, industrial, and environmental contexts. The map below shows the geographic location of Methane and Health Dialogue Series attendees.



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SRON Netherlands Institute for Space Research

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Compiled Slides of Sector Report-Outs

Oil and Gas Report-out

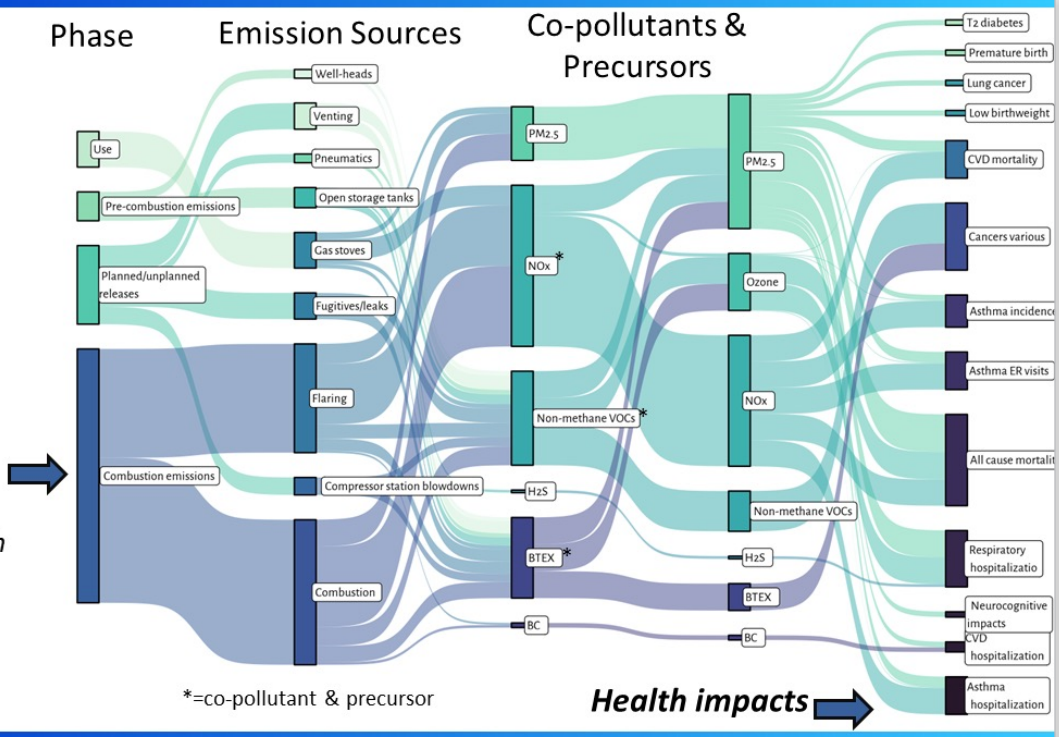
EDF Methane and Health Dialogue Series

May 10, 2023

Environmental Defense Fund

Assessing methane emitting activity health impacts: *a focus on air pollution*

Height identifies the frequency of sources identified during breakout sessions and does not reflect strength of association



Emerging priorities: Broad scale

- Match new monitoring technologies and data sources
  - Methane satellites
  - Infrastructure mapping
  - Natural gas co-pollutant concentration datasets
  - International leverage
- Life-cycle approach to regulation/solutions: e.g. “Methane Intensity”
  - Upstream:
    - Limit leases of public land
    - Require setbacks from sensitive locations
  - Downstream:
    - Bans on new gas hookups
    - Promote and subsidize electrification

Emerging priorities: Site/local scale

- Application of best practices
  - Electrification of compressors, other sources of onsite combustion
  - Improved flaring technologies
  - Improve and replace seals on compressors, tanks, wells, etc.
- Re-engineering
  - Reducing venting
  - Reducing flaring by capturing gas rather than burning
- Monitoring
  - Use data to ID new constituencies, illuminate inequities
- Community engagement/public education
  - Listen to affected community priorities and concerns
  - LDAR/monitoring around site boundaries

Key questions & gaps

Key Questions

- Framing of methane emitting mitigation strategies that impact health
  - *Who are they for? What **audience** do we have in mind?*
  - *Who benefits and who implements?*
- How can inspection or other processes be leveraged, and what other levers do we have to improve enforcement?

Gaps & challenges

- No existing way to regulate transboundary emissions
- Lack of enforcement of existing regulations
- Lack of monitoring data
- Emissions inventory resolution
- Consistent ratio between methane and co-pollutants has not been identified
- Offshore-production regions, e.g. Southeast Asia, may have different health priorities

Agriculture Report-Out

EDF Methane and Health Dialogue Series

May 10, 2023

Environmental Defense Fund

AGRICULTURE

Optimizing livestock productivity

Through strategies to improve animal health, nutrition, adaptation/resilience

Improved human health

Improved human food securi
health, and livelihoods

+

Climate mitigation

Through methane emissions intensity reductions

Pathways for Impact on Human Health and Methane Mitigation

Feed sources *Upcycle industrial/food waste*	Feed *Improve animal nutrition*	Animal *Improve animal health* *Improve animal breeding* *Improve animal resilience*	Manure *Improve manure management, incl. recycling, biogas, BSF, etc.*	Animal Source Foods *Reduce food waste*	Rice *Implement appropriate flood and fertilizer management*
	→ Increase quantity and quality of animal source foods to improve human nutrition, health, livelihoods		→ Reduce transmission of diseases and contamination of products → Reduce fine particulate matter	→ *See waste discussion*	→ Reduce ground level ozone
→ *See waste discussion*	→ Reduce aflatoxin contamination of milk	→ Reduce morbidity and mortality that cause loss of production, require additional labor/resources → Reduce human exposure to pest control agents → Reduce antibiotic use, AMR → Reduce zoonotic disease transmission to humans			

Near-Term Opportunities

- **Improve animal nutrition**
  - → Develop extension program training, expand co-op support
- **Improve animal health**
  - → Develop extension program training
  - → Provide easier access to vaccines, veterinary care, disease surveillance/control
- **Improve animal management**
  - → Develop extension program training
- **Improve manure management**
  - → Encourage incentives for implementation for sustainable development
- **Upcycle industrial/food waste**
  - → Investigate opportunities and drivers for implementation
- **Implement appropriate flood and fertilizer management for rice production**
  - → Provide technical support

Near-Term Gaps & Needs

- **Quantify the relationship between specific interventions to optimize productivity** (improve animal nutrition, improve animal health, improve genetics, etc.) **and emissions reductions** (absolute and intensity)
  - Differences between breeds, regions, etc.

- **Quantify the relationship between optimized production and human health benefits**, esp. in LMIC

- **Increase research, development, and extension funding for understanding feed and emissions, animal health and emissions, etc.**

Longer-Term Opportunities & Needs

- **Breeding strategies**
- **Regional/national policies and infrastructure** promoting best practices
- **Expand understanding of microbiome and methane production** in cattle
- **Develop effective markers and models** for methane emissions from cattle under various scenarios
- **Understand and address cultural barriers and traditional practices for effectively managing animal numbers and targets** in different settings, such as traditional rangelands

Key Questions & Gaps

- What are the evidence-based impacts and key drivers for implementing these practices?
- Who is our audience for this messaging?

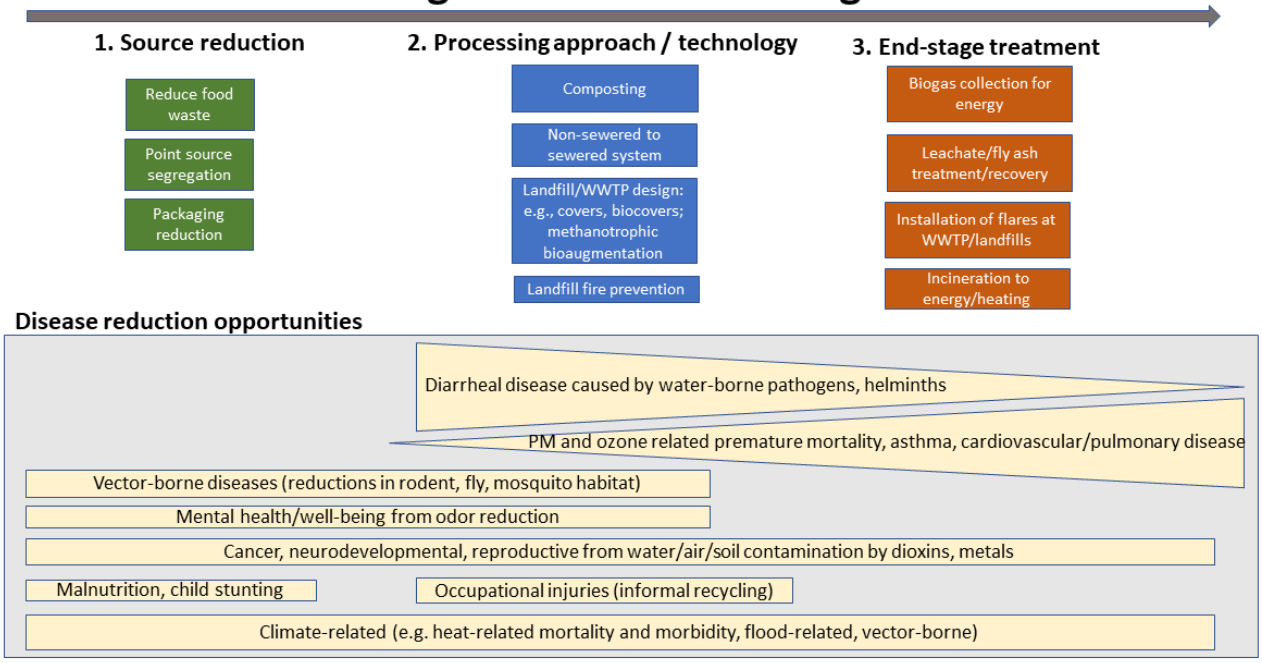
Waste Sector Report-Out

EDF Methane and Health Dialogue Series

May 10, 2023

Environmental Defense Fund

Health benefit opportunities across waste management strategies for methane mitigation



Near-term opportunities to optimize health benefits

- Improve access to carbon markets for sanitation sector through better methane measurement technology, esp. for small (but numerous) point sources (ground and remotely sensed)
- Capitalize on odor complaints as a primary driver for action/enforcement at landfills
- Build coalitions with agriculture and nutrition sector on opportunities for source reduction/circular economy strategies (↓ food waste, waste to compost)
- Build coalitions with environmental and climate justice organizations focusing on health impacts from landfills/WWTP

Longer-term needs for building the evidence-base to realize health benefits

- Quantify diarrheal disease reductions from strategies in non-sewered systems (e.g. pit latrine → above ground to composting) and sewered systems (e.g. water contamination from overflows, methane leakage from aging infrastructure)
- Evaluation of community-based, ground-level air and water quality sensor data, odor complaints and documented methane reductions from waste management systems for landfills and incineration.
- Characterize community health benefits from source reduction strategies and composting in food and agriculture sector (e.g. nutritional benefits, vector control)

Note: These tables represent working products from each of the sector specific breakout groups.

SECTORAL TABLES

Agriculture Sector: Activities to Reduce Methane and/or Improve Health Outcomes

April 11, 2023, Ag Sector Breakout Group Work

Strategy	Intervention	Human health improvement outcomes? Is the impact quantifiable?	Methane emissions reduction outcome? Is the impact quantifiable?	Opportunities to implement or support the intervention to reduce methane and improve human health? Specific ways to quantify impacts?	Drivers (e.g. policy, financial incentives) of intervention implementation and audience
Improve animal nutrition	Provide sufficient feed during dry seasons, improve ration balancing, feed selection and management, feed additives to increase production	Increase quantity of milk, improve quality of animal products	Reduce methane emissions intensity Quantify the emissions of various feeds and feeding regime from various animal types and breeds.	Quantify the links between human nutrition and improved animal production esp. in the context of LMIC	Extension program training RD&E funding for feeds and emissions Increased production greater than cost of intervention
Improve animal health	Improve udder hygiene, vaccines, herd management Biosecurity, control of internal and external parasites (incl. ticks), access and infrastructure for veterinary care, disease surveillance and control, etc., targeted anti-helminthic use	Increase quantity of milk, improve quality of animal products; reduce mastitis, other diseases of cattle that require additional labor; less acaricide use reduces human exposure to acaricides; reduce antibiotic use; reduce zoonotic disease transmission to humans	Reduce methane emissions intensity Quantify the link between animal health and emissions intensity	Farmers utilize milking hygiene Easier access to vaccines Quantify the links between human nutrition and improved animal production esp. in the context of LMIC	Regional/national policies regarding vaccination for certain diseases RD&E funding for animal health, health and emissions
Improve reproduction	Reduction in intercalving interval, increased numbers of progeny, more resilient youngstock	Increase quantity of milk, improve quality of animal products ▶ can measure amount of milk/meat produced, content	Reduce methane emissions intensity		
Improve animal resilience/ adaptation	Improve feed efficiency and drought tolerance genetics; reduce heat stress through shade, feeding, genetics, sprinklers	Increase quantity of milk, improve quality of animal products ▶ can measure amount of milk/meat produced, content; increased temp decreases water and DM intake and causes reduced BW of animals	Reduce methane emissions intensity Quantify the links between genetics, feed use efficiency and emissions		

Strategy	Intervention	Human health improvement outcomes? Is the impact quantifiable?	Methane emissions reduction outcome? Is the impact quantifiable?	Opportunities to implement or support the intervention to reduce methane and improve human health? Specific ways to quantify impacts?	Drivers (e.g. policy, financial incentives) of intervention implementation and audience
Improve breeding strategies/selective breeding	Improve genetics for increased productivity, reduced methane emissions, improved feed efficiency index (FEI), better health, increased drought tolerance, reduced heat stress, selection of "efficient" traits (recent research area) Identify phenotype for methane emissions and co-associations with other phenotypic traits Identify breeds that are best suited by region	Increase quantity of milk, improve quality of animal products ▶ can measure amount of milk/meat produced, content Nutritional traits (milk fat, leanness, etc.) can be selected as part of the effort to gain efficiency	Reduce methane emissions intensity Quantify the links between genetics, feed use efficiency and emissions		
Management strategies	Loose housing to reduce stress and disease, increase productivity In traditional rangelands settings, adjust cultural barriers and traditional practices towards effectively managing animal numbers and targets	Increase quantity of milk, improve quality of animal products; reduce zoonotic disease transmission to humans Understand changes on health of communities	Reduce methane emissions intensity Manage animal numbers and link to markets to reduce emissions	Use participative rangeland management approaches to manage transitions and link to community health	Cultural drivers for animal keeping Work with communities and governments to better manage communal rangeland systems
Feed/feeding management practices	Change feeding regimens; reduce aflatoxin contamination	Reduce aflatoxin contamination of milk for human consumption	Reduce methane emissions intensity		
Manure management	Follow principles of circular economy/recycling; Black Soldier Fly (BSF) use, Biogas	Reduce transmission of diseases (from manure), contamination of products; can lead to negative health impacts through disease if not properly managed	Reduce methane emissions from manure		
Industrial/food waste management	Follow principles of circular economy/recycling	Proper food waste treatment can eliminate disease vectors	Reduce methane emissions from landfills (avoided emissions); prevent leaching-related pollution	Feeding food waste to cattle (upcycling)	Study feeding citrus to lactating dairy cows measuring methane emissions and productivity
Dairy and meat product waste management	Reduce food waste				
Rice methane	Implement appropriate flood and fertilizer management				

Oil and Gas Sector: Activities to Reduce Methane and/or Improve Health Outcomes

April 11, 2023, Oil & Gas Sector Breakout Group Work

Mitigation Strategy	Source of CH4	Health Impacts
Electrifying compressors Electrify other engines and source of combustion on site – reduce NO_x and some other emissions Improving the seals on compressors: better quality, replace aging seals Regulation is needed to force industry to install state of the art equipment	Combustion	Co-pollutants NO_x, VOCs, HAPs, BTEX, Black Carbon, and other components of primary PM have multiple health impacts: • Respiratory • Cardiovascular • Neurodegenerative
Technologies to improve flares	Flaring, other incomplete combustion	Co-pollutant Black Carbon has multiple negative health impacts: • Respiratory • Cardiovascular • Ecosystem health effects • Interaction with Ozone causes synergistic health effects
Superemitter response program Capture rather than vent gas: re-engineering of infrastructure	Pre- combustion emissions: Venting, emissions of pre-combusted methane and other co-pollutants at point of production (wellheads, pneumatics, tanks) Operation of compressor-station blowdowns: operation that occurs intermittently – maintenance process to clean out gas or readjust pressure. Hours long release of unburned gas, usually unannounced	Quantification: if there was consistent data on frequency of blowdowns, could probabilistically estimate when it might happen. Would need to quantify volume of gas involved. Gas in blowdown: likely floor is the composition of unburned gas from stoves; likely higher concentrations. Health impacts depend on local meteorology and location of communities Quantification and emissions inventory is critical: inspecting in-situ emissions observations: methane and other co-pollutants are being dramatically underestimated. Forthcoming contributions from satellites can help a lot.
	Leaks in transmission and distribution pipelines	HAPs and hexane leaked along with methane
		Methane is a precursor to Ozone, which leads to: • Cardiovascular disease • Respirator disease • Premature death • Reduced crop yield • Impacts on ecosystems (e.g. forests) leading to health impacts
Community-based solutions: Develop inclusive approaches to working with communities; inform communities and give them tools to push for accountability	Poor enforcement of existing regulations on CH4 emissions	Increased emissions of methane and other air pollutants
	All CH4 emissions sources	Climate Change affects human health in a variety of ways (vector borne diseases, heat exposure, floods/storms, food supply.); also causes feedback cycles exacerbating climate change's effects
	Subsurface stray gas	Contaminates private wells, particularly in more arid regions

Mitigation Strategy	Source of CH4	Health Impacts
	Venting – onshore wells (e.g. in MX) focused on oil, release associated gas being produced Storage tank with top left open, all volatile gasses released to air Not fugitive, not due to combustion	Documented in 2 regions – one had high concentration of H2S and was mitigated, the other didn't and was not Communities nearby – methane is lease of their issues
	Orphaned and abandoned wells	
Methane emissions response program – based on "empirical and accurate" estimates of emissions		
Can methane measurements be combined with estimates of ratios with other copollutants? Global observations.of methane from oil and gas around the world? How can we leverage that data for health implications? NO_x is a strong driver of health impacts – potential to ID ratios		

Waste Sector: Activities to Reduce Methane and/or Improve Health Outcomes

April 11, 2023 Waste Sector Breakout Group Work

WASTEWATER

Health issues from exposure to human waste	Intervention, technology, or strategy	Will this intervention improve health outcomes? Is that impact quantifiable?	Will this intervention reduce methane emissions? Is that impact quantifiable?	Opportunities to reduce methane and improve health outcomes?
Diarrheal disease caused by water-borne and/or soil-borne exposure to human waste related pathogens	Diversion of fecal sludge from pit latrines to compost or other re-use	Unclear? Does exposure to fecal sludge increase with compost systems but also possibly decrease via water contamination route?	To some extent	Missed opportunities for circularity between waste and agriculture-nutrition Exposure to pathogens in latrine leachate and other water contamination Odors/other nuisance associated with pit latrines
	Better management of septic tanks/fields	Good health evidence for reductions in exposure to soil-related helminths	Not sure. [Recent research suggests EPA/IPCC estimates are underes-timating methane emissions in US (Princeton Group)]	
	Better management of municipal wastewater treatment plants	Good health evidence that WWTP overflows (e.g. during flooding events) increase GI related visits to ED etc.		Not sure – I'm not familiar with how methane mitigation works for wastewater treatment plants and if it would also prevent overflows
	Capturing biogas from well-managed latrines can be used as a household/ farms energy source	Improving the quality of the environment in countries. There is a lot of information about rural areas without sanitation that have health problems related to water quality (e.g. digestive, skin, problems)	Yes. Depending on the strategy to improve the non-sewered sanitation systems (pit latrines, septic tanks). It is possible.	

Health issue	Intervention, technology, or strategy	Will this intervention improve health outcomes? Is that impact quantifiable?	Will this intervention reduce methane emissions? Is that impact quantifiable?	Opportunities to reduce methane and improve health outcomes?
PM-related premature mortality, asthma, cardiovascular/pulmonary disease	Potential to use monitoring data to predict landfill fire events	PM-related health outcomes easily quantified Attribution to acute landfill fires difficult		
	Reduction in incineration	Attribution to incineration difficult, some examples for larger incineration facilities in literature		
Cancer, neurodevelopmental, reproductive	Linters that collect leachate, and treatment through anaerobic digestion or recirculation	Leaching of toxic chemicals (dioxins, metals, PAHs) into soil and water, ash and wastewater from incinerators/landfills	Leachate has a high organic load, so its management should reduce greenhouse gas emissions	
	Reduction in incineration, landfill fires	Inhalation of hazardous air pollutants (dioxins, metals, PAHs)		
Improved food security, nutrition, reduction in child stunting	Point source segregation of organic waste and collection Policies that promote public and private point source segregation and collection Policies and standards to promote and provide clear value chains for end-use products (i.e., compost and biogas)	Reducing food waste has benefits if that food reaches people Reduction in waste leads to more efficient food system and more food security Composted waste can in turn be used to improve soil and food productivity Leachate with less biological oxygen demand (easier to manage and less impacts to environment and health)	Methane reduction linked to the end treatment of organic waste	Reduce food waste, cold chains, packaging reduction approaches, diverting still edible food via hunger programs Increases the lifetime of landfills and reduces municipal costs
Physical injury (e.g., operators, community members, recyclers, injury from slides)	Better practices in the operation of facilities Activate well-managed emergency cells Supporting the creation of sanitary landfills with active biogas collection systems Formalizing informal recyclers and/or paying for services or benefits	Improved practices could address injury, as well as health related issues like PM exposure, respiratory impacts, exposure issues	Yes	Note: Indicators linked to Stockholm and Montreal Agreements Note: Suggest Promote a voluntary carbon market so that money can be used to improve health and operational issues identified in landfill operations

Health issue	Intervention, technology, or strategy	Will this intervention improve health outcomes? Is that impact quantifiable?	Will this intervention reduce methane emissions? Is that impact quantifiable?	Opportunities to reduce methane and improve health outcomes?
Ozone-related premature mortality, asthma, cardiovascular/pulmonary disease	Installation of flares at WWTP and landfills In-site use or redirection of methane to the grid Biocovers; methanotrophic bioaugmentation Better operational practices at landfills and biogas facilities Improved monitoring for leaks Capacity building for local operators and community members	Yes, reduction of ground-level ozone (quantified in GMA)	Flaring stacks can quantify the flow leakage from anaerobic digestion Energy production can be quantified Reduced Methane venting and flaring (this applies to both waste water and solid waste) Consider utilizing GHG inventories (baseline versus new data) as a source of information	Policy regulations: - Ban routine venting - If venting cannot be avoided, choose flaring - Flaring efficiency of 98% or greater Quantify biogas production before and after leak detection In-situ solutions for local/rural areas
Vector-borne disease (rodents, flies, mosquitos)	Centralized waste collection Packaging reduction Point source segregation Biocovers Plastic bans Non-sewered to sewered	Waterways clogged with inadequately managed waste (e.g. plastics and tires as mosquito breeding grounds) Uncovered food and human waste attracts flies, rodents		
Mental health, well-being improvements from odor reductions	Non-sewered to sewered systems, better management on sewered systems Installation of flares at WWTP and landfills In-site use or redirection of methane to the grid Biocovers; methanotrophic bioaugmentation Capacity building for local operators and community members.	Yes, hard to quantify quality of life, mental health impacts (stress); consider data from health studies in the vicinity of landfills	Yes, through remote sensing platforms	Set up citizen surveillance system for odors; odors can be used as an indicator of other atmospheric pollution
Climate-related health outcomes (e.g. heat-related mortality)	Installation of flares at WWTP and landfills In-site use or redirection of methane to the grid Biocovers; methanotrophic bioaugmentation	Yes—heat-related quantified in GMA, many other unquantified climate-related health benefits (flood-related, vector-borne, etc.)	Yes, through remote sensing platforms	

Note: the table below represents contributions during the sessions and have not been edited.

SESSION 3 TABLE – PATHWAYS FOR ACTION

EDF Methane and Health Dialogues: Ideas about Path Forward to Build Support for Action

May 10, 2023

	Agriculture	Oil and Gas	Waste	General: All Sectors
Audience: **Who else should we engage in the conversation?**	Donors such as USAID, BMGF Livestock team, Bezos foundation etc. Nutritionist, family doctors Interdisciplinary scientists, veterinarians Policy makers - Ag Committee (Farm Bill, US Congress) Policy makers especially animal husbandry department/ ag department, journalists, health care department. Civil society, national research organizations working for ag sector Folks working on nutrition policy, dietary guidelines, malnutrition - Natl Academy Medicine, NASEM, NAP, USDA, ANA, Congress Farming community and relevant science and service sectors, such as Agronomy, Soil, Animal Sci., Feed industry that source and supply feedstuffs to producers Agricultural (consumer product goods) companies Veterinary pharmaceutical industry	Doctors working with local communities. People who are in organized civil society, living in communities affected by oil and gas infrastructure Pediatricians, respiratory health professionals Lawyers around land use in agricultural areas Air Quality Regulators Insurers (risk of inadvertent harm though) Oil and Gas Industry; technology experts Environmental and health ministers	Water, sanitation, and hygiene (WASH) specific organizations (e.g. IRC, IWA, WaterAid, also Gates Foundation, Sustainable Sanitation Alliance) Agricultural organizations/USAID, to promote circular economies between waste and agriculture around nutrient recycling from composted waste Dietitians and Nutritionists Respiratory & cardiovascular health professionals (re air pollution aspect) Oil palm processors Human rights defenders and litigation organizations, CEJIL for example Food banking organizations, like GFN, REfed, among others Environmental Justice organizations like GAIA	Health community Convention on Long-Range Transboundary Air Pollution and Gothenburg Protocol (UNECE) Carbon market experts, especially those with an understanding on how to link markets to small scale farmers/waste managementcenters Governments participating in the Global Methane Pledge (who'd like to know the health benefits of mitigation) One Health communities (IPCC, FAO, USDA, etc)- interconnections between methane and ecosystem/wildlife health, diseases, biodiversity Climate and Health education community (GCCHE/Columbia, GCHA, ASPPH, WHO) Climate and Health Equity community (White House OCCHE) - health sector emissions including methane and health impacts/disparities and global health pledges Veterinary education. Research, and clinical practice community (AAVMC, AVMA)

	Agriculture	Oil and Gas	Waste	General: All Sectors
Products or Materials: **What information do these audiences need to advance a specific intervention or, more generally, broaden awareness of the linkages between methane and health?**	An understanding of the linkages between ag & health, quantification of emissions and potential for management to reduce Methane Emissions in Livestock and Rice Systems – Sources, quantification, mitigation and metrics This document outlines where we are with methane mitigation Education about the impacts of the short term climate impacts of methane Data and information how methane emission- animal productivity and impact human health relations. mapping methane	Types of MRV technologies available, vendors (comparative) Informational materials connecting methane and co-pollutants that impact health Legal community who can help build legal toolkits for siting/permitting Technologists or VCs who can boldly think outside the box to invest in time and energy for innovative mitigation solutions that have high risk/high reward (I added here since I was thinking of methane leaks; but this approach can span all sectors)	Regionally prioritized WASH interventions that also have methane reduction benefits Quantitative data linking sanitation interventions to both health benefits and methane emissions reductions Link to worker health and safety (OSHA) Sustainable food systems and diets Cogeneration co-benefits and cost for example with the cement industry	GCHA Reports on Methane and Health - designed for health community; anticipated in July Infographics, short videos Forthcoming PSE dispersion modeling tool focused on hazardous air pollutants (e.g., benzene) from gas loss of containment events/methane plumes to quantify air quality impacts and evaluate human health risks. This will begin with the O&G sector (upstream, midstream and downstream) and then hopefully include the landfill sector (pending resources) Comparison of methanogenesis across different methane generating environments to provide new insights on mitigation strategies National level impacts of co-emissions on health to complement the results for ozone/health already available from the GMA Broad-scale cost-benefit analysis of mitigation strategies that incorporates health
Activities and Events: **Where might we engage these stakeholders? Are there activities and events scheduled that could be leveraged?**	Dedicated farmer workshops & meetings; run by levy boards, regional/ national farming organisations, animal health organisations and cooperatives Monitor farms to demonstrate best practice to peers with quantitative measures of methane and co-pollutants - similar to oil and gas we need local toolkits in agricultural communities 1. national conference to engage all actors in one platform. 2. create a national platform for reduction of methane- should we include in the government existing events- like national policy meetings	Medical and public health conferences Regulator toolkits and trainings Tech/industry conferences Legal conferences Webinars and workshops addressed to influencers and organized civil society in local communities that can help to raise awareness Toolkits addressed to local communities with information on health impacts and legal action they can take	IWA International symposium on health-related water microbiology World Toilet Day Training nutrition and dietetic profes-sionals International Solid Waste Association World Congress, late October 2023 Global Waste Management Symposium	Intersessional mtg - Bonn (June) World Health Summit, Berlin National Level Health Meetings; Sector specific health mtgs Regional health weeks (e.g. ACW) Regional Climate weeks, sept-oct (https://unfccc.int/climate-action/ regional-climate-weeks) COP28 (Nov/Dec) - to include a health day

	Agriculture	Oil and Gas	Waste	General: All Sectors
Activities and Events: **Where might we engage these stakeholders? Are there activities and events scheduled that could be leveraged?**	The science community needs to bring the topic and linkages between ag & health more into papers and conferences, so raising donor funding for the topic will facilitate this Focused convenings - is a good way to explore the topic and connect the donors to the issues. Engaging feed industries: what have been done and what opportunities/ concerns/ obstacles regarding food and barrage processing residues/ wastes to be used for livestock- based upcycling Events for consumers- create awareness through exhibition for climate friendly products- like agri forum/farmers platforms/health forums happens every year- include this agenda			Dedicated workshops with health professional groups to inform, build interest, and explore potential for engagement. [Jeni] World health assembly; next May 2024 CCAC meeting in Bangkok Social media A hub / information portal for all things related to Methane [from Sources to Impacts to Mitigation, etc.]

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