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Dipartimento di Agraria

# Using GWP\* to assess the GHG livestock emission impact: the Italian case study



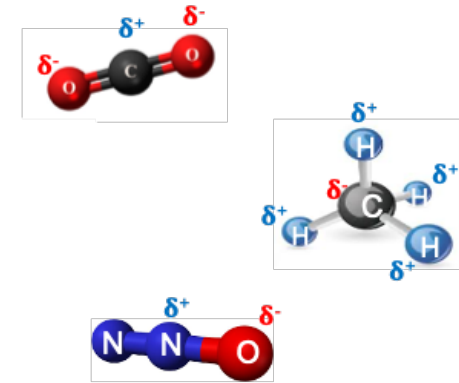
**The 75<sup>th</sup> EAAP Annual Meeting**  
**1/5 September 2024 - Florence, Italy**

**Fabio Correddu**  
Mondina F. Lunesu  
Maria Francesca Caratzu  
Sara Sechi  
Giuseppe Pulina

Greenhouse-gases (GHG) are similar for their ability to interact with infrared radiation, thank to their molecular characteristic: electric dipole.

However, GHG are very different in term of radiative forcing and in term of time permanence in the atmosphere.

This last point makes a big difference in term gas accumulation and then in term of impact on temperature

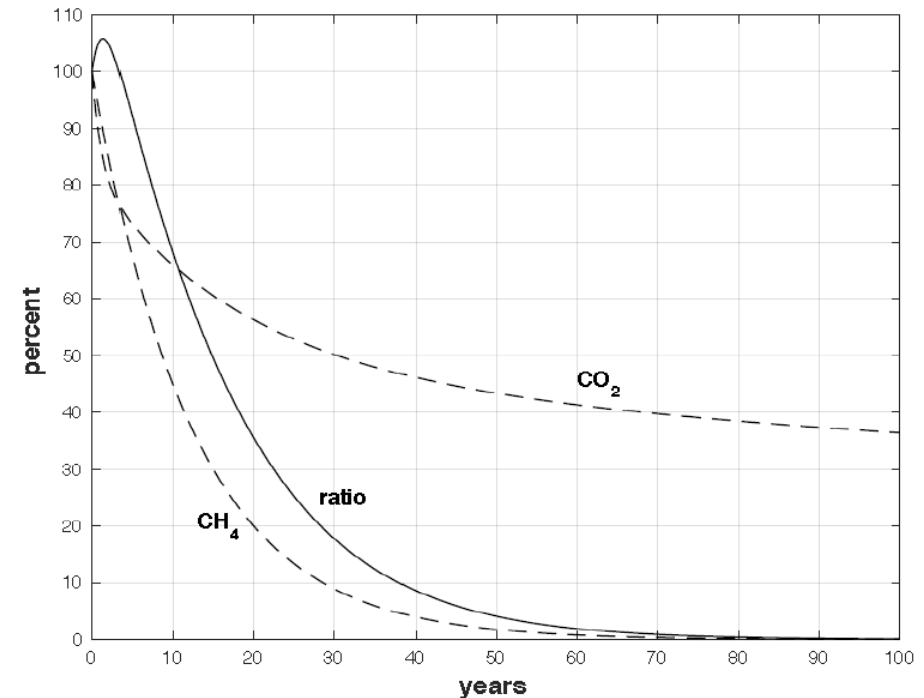


| Common name    | Chemical formula | Radiative forcing (W/m <sup>2</sup> per ppb) | Half-life (years) |
|----------------|------------------|----------------------------------------------|-------------------|
| Carbon dioxide | CO <sub>2</sub>  | 1.4x10 <sup>-5</sup>                         | >1000             |
| Methane        | CH <sub>4</sub>  | 3.7x10 <sup>-4</sup>                         | 12                |
| Nitrous oxide  | N <sub>2</sub> O | 3.03x10 <sup>-3</sup>                        | 114               |

Methane has a half-life of 8-12 years and is almost completely removed after 50 years (**short lived climate pollutant SLCP**), while CO<sub>2</sub> resides in the atmosphere for over a century (**long lived climate pollutant, LLCP**)

### Global Warming Potential (GWP<sub>100</sub>)

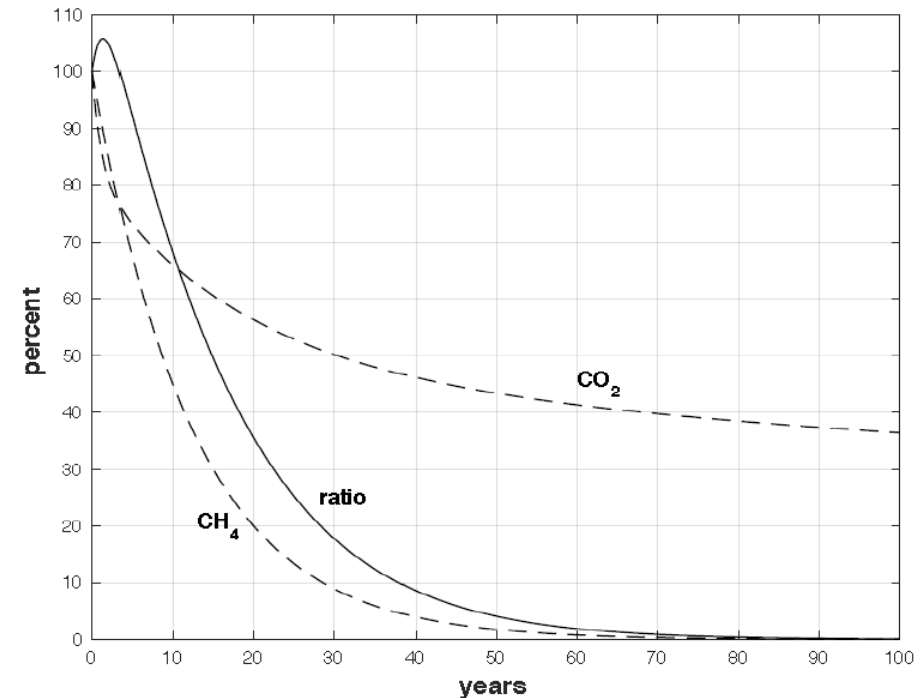
|                                   |     |
|-----------------------------------|-----|
| Carbon dioxide (CO <sub>2</sub> ) | 1   |
| Methane (CH <sub>4</sub> )        | 28  |
| Nitrous Oxide (N <sub>2</sub> O)  | 265 |



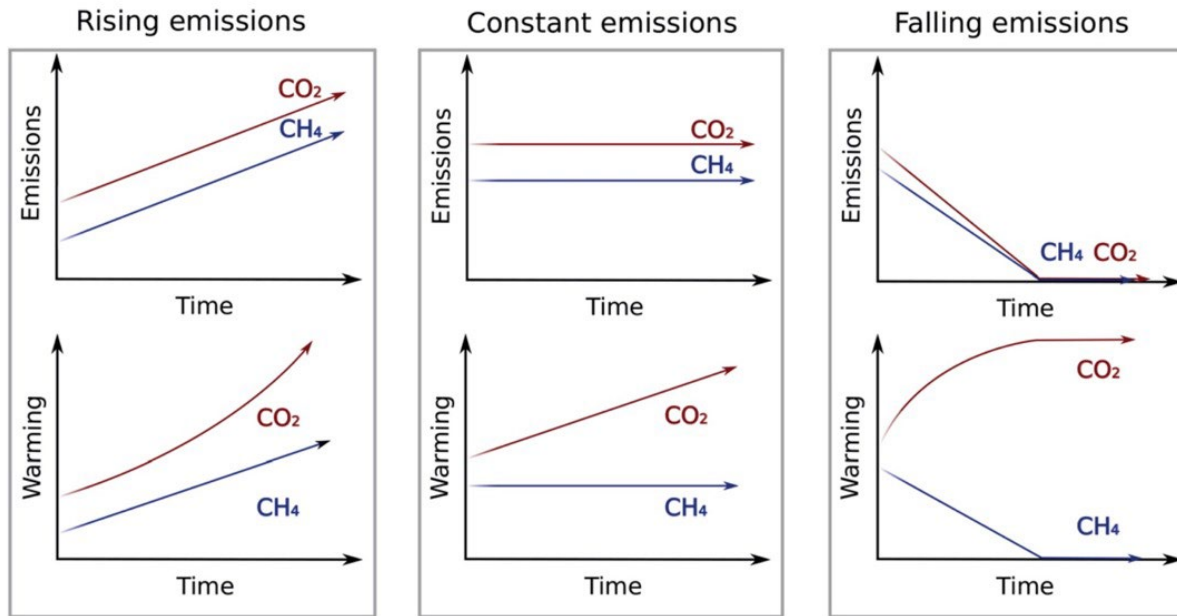
**Figure 1:** The persistence of carbon dioxide and methane in the atmosphere as a function of time. The chart begins when a pulse of the gas is injected into the atmosphere. The legacy effect of methane is miniscule compared to that of carbon dioxide.

Methane has a half-life of 8-12 years and is almost completely removed after 50 years (**short lived climate pollutant SLCP**), while CO<sub>2</sub> resides in the atmosphere for over a century (**long lived climate pollutant, LLCP**)

**No metric can accurately compare all the consequences related to different emissions, and all have limitations and uncertainty (IPCC, 1990)**



**Figure 1:** The persistence of carbon dioxide and methane in the atmosphere as a function of time. The chart begins when a pulse of the gas is injected into the atmosphere. The legacy effect of methane is miniscule compared to that of carbon dioxide.



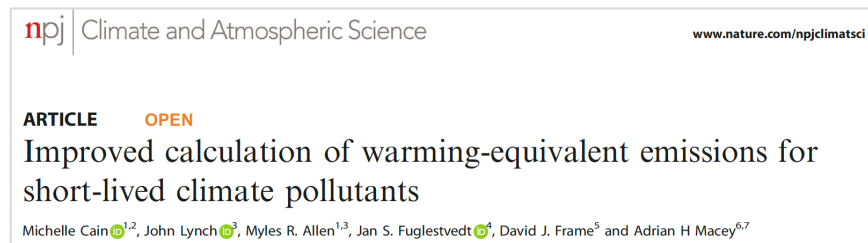
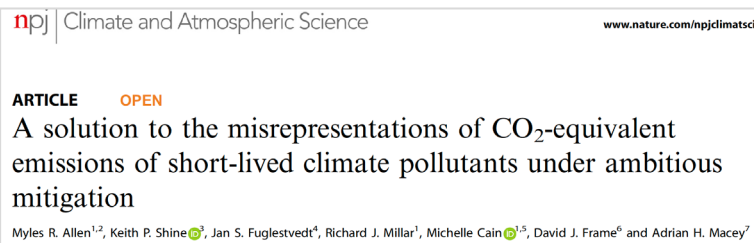
## Climate metrics under ambitious mitigation



Authored by: Myles Allen, Michelle Cain (University of Oxford) and Keith Shine (University of Reading). Published by the Oxford Martin Programme on Climate Pollutants

The standard IPCC GWP<sub>100</sub> falls to take into account these differences

A metric that reflects the equivalence between CH<sub>4</sub> emission rates and cumulative emissions of CO<sub>2</sub> can overcome this problem



## Evolution of Global Warming Potential [GWP ( $ECO_2-e$ ) vs GWP\* ( $ECO_2-we$ )]

$$\text{GWP} \quad ECO_2-e = E \times GWPH$$

IPCC, 1990

$$\text{GWP*} \quad ECO_2-we = (\Delta ESLCP / \Delta t) \times GWPH \times H$$

Allen et al., 2018

$$\text{Evolution of GWP*} \quad ECO_2-we = GWPH \times [r \times (\Delta ESLCP / \Delta t) \times H + s \times ESLCP]$$

Cain et al., 2019

- $E$  is the mass emission for a GHG and  $H$  is the forward time horizon and  $GWPH$  is the GWP for a GHG as according to IPCC (1990) over time horizon  $H$ .
- $\Delta ESLCP$  is the variation of emission rate of a SLCP over the time interval  $\Delta t$ ,  $H$  is the forward time horizon.
- $r$  and  $s$ : weight of the cumulation ( $s$ , stock) and emission rate ( $r$ , rate) for a given time  $H$ . Calculated using a multiple linear regression onto the response to methane emissions in commonly used scenarios, focusing on the time period 1900–2100.  $r = 0.75$ ,  $s = 0.25$ .

simplified GWP\*  
for 20 years

$$ECO_2-we = GWP_{100} \times [4.53 \times ESLCP(t) - 4.25 \times ESLCP(t-20)]$$

Smith et al., 2021

## Using GWP\* to assess the GHG livestock emission impact: the Italian case study

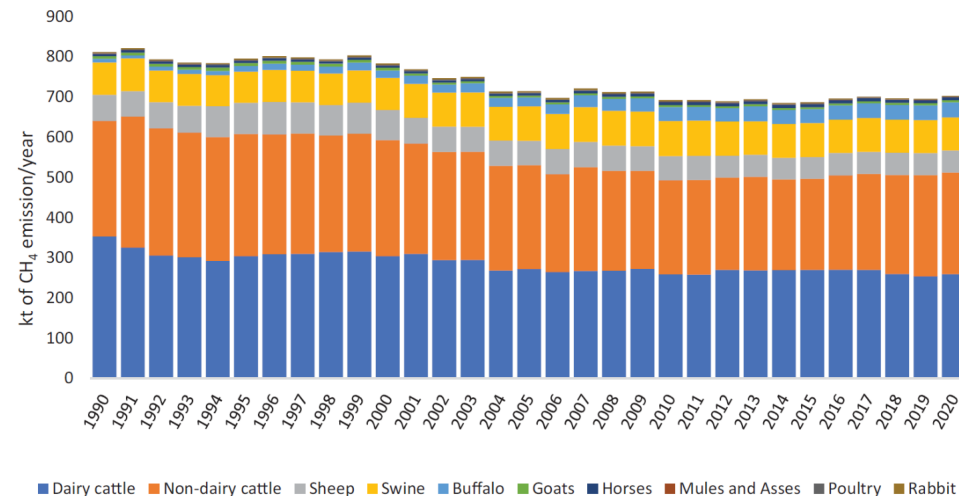
ITALIAN JOURNAL OF ANIMAL SCIENCE  
2023, VOL. 22, NO. 1, 125-135  
<https://doi.org/10.1080/1828051X.2023.2167616>



### Recalculating the global warming impact of italian livestock methane emissions with new metrics

Fabio Correddu , Mondina Francesca Lunesu , Maria Francesca Caratzu , and  
Giuseppe Pulina

Dipartimento di Agraria, Università degli studi di Sassari, Sassari, Italy



**Figure 2.** Livestock methane (CH<sub>4</sub>) emissions in kilotons (kt) from 1990 to 2020 (Romano et al. 2021) from International Panel on Climate Change (IPCC)'s emission category 'enteric fermentation' and 'manure management systems' (IPCC 2019).

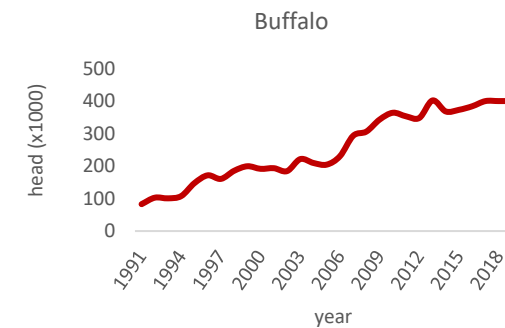
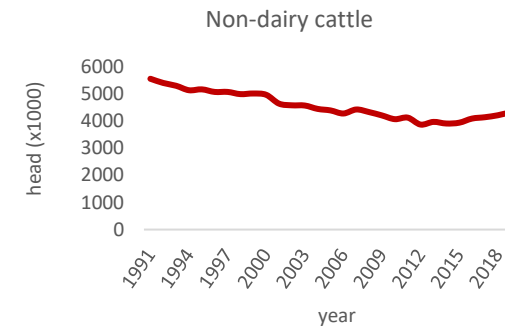
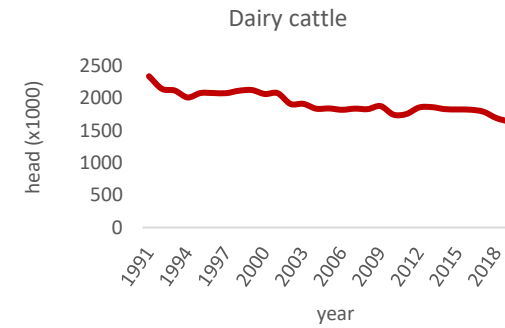
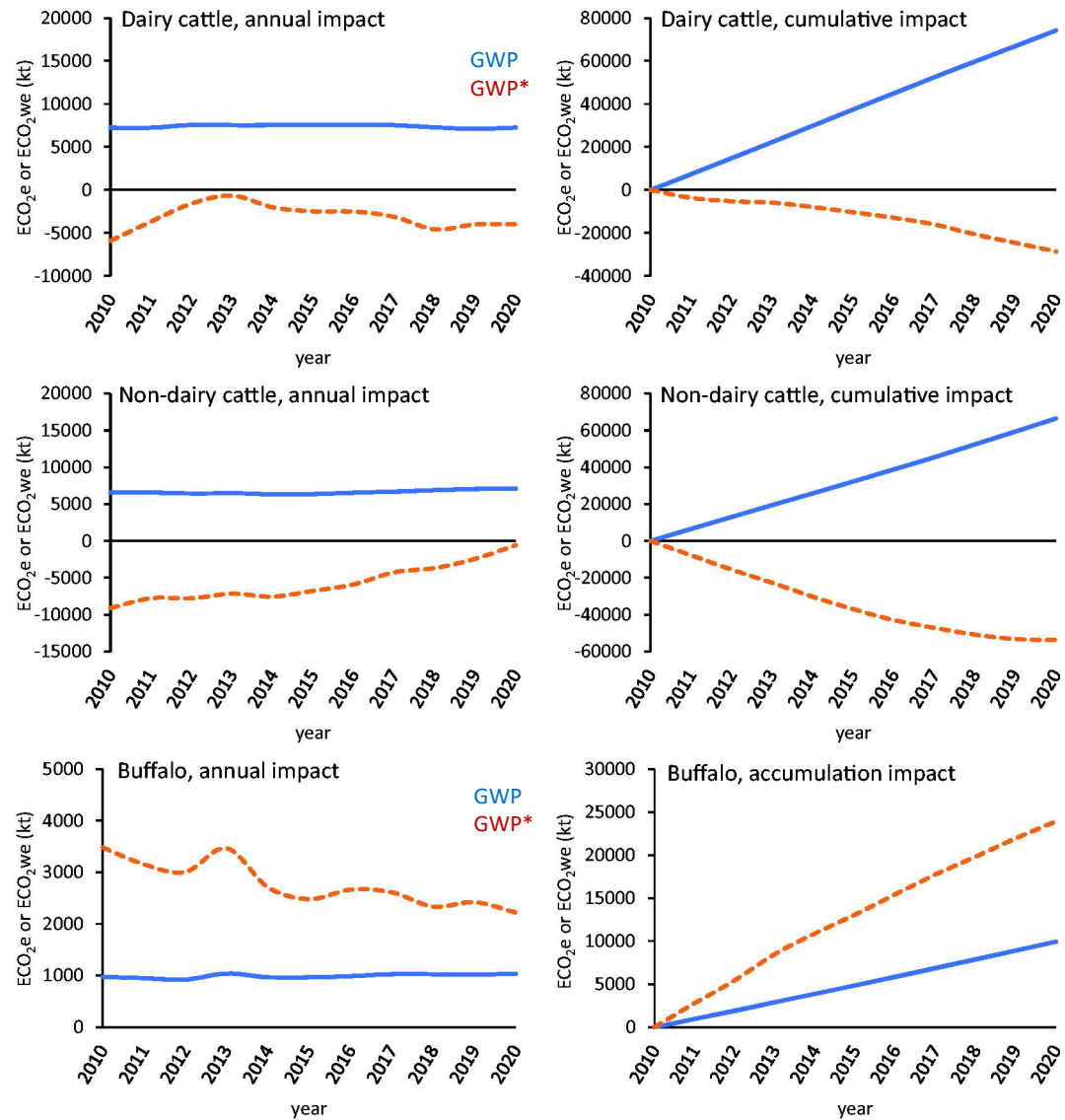


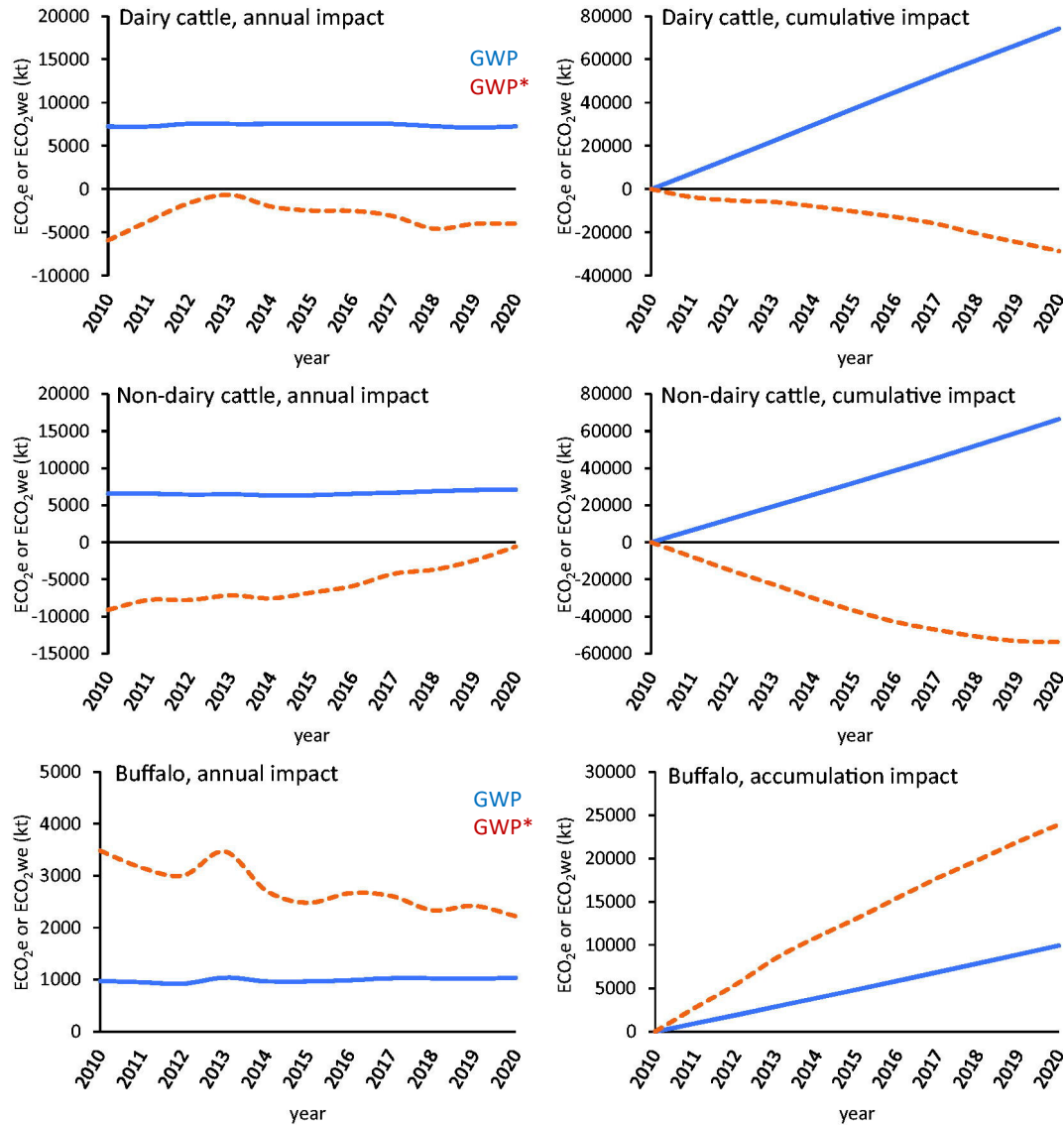
Italian government agency for environmental monitoring  
(ISPRA 2022)  
'enteric fermentation' and 'anaerobic digestion of manure'  
from 1990 to 2020 mainly based on the TIER2 approach.



Using GWP\* to assess the GHG livestock emission impact:  
the Italian case study

# RESULTS





Liu et al. *CABI Agric Biosci* (2021) 2:22  
<https://doi.org/10.1186/s43170-021-00041-y>

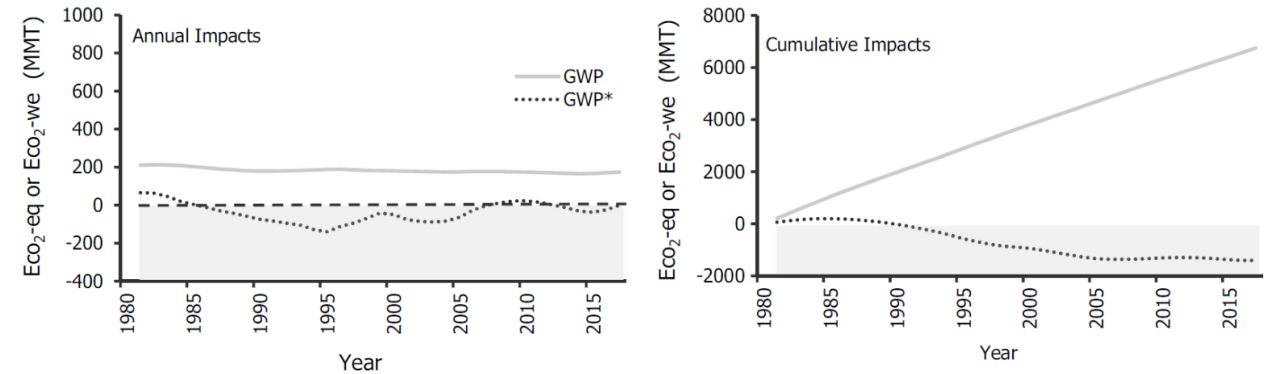
CABI Agriculture and Bioscience 

RESEARCH

Open Access

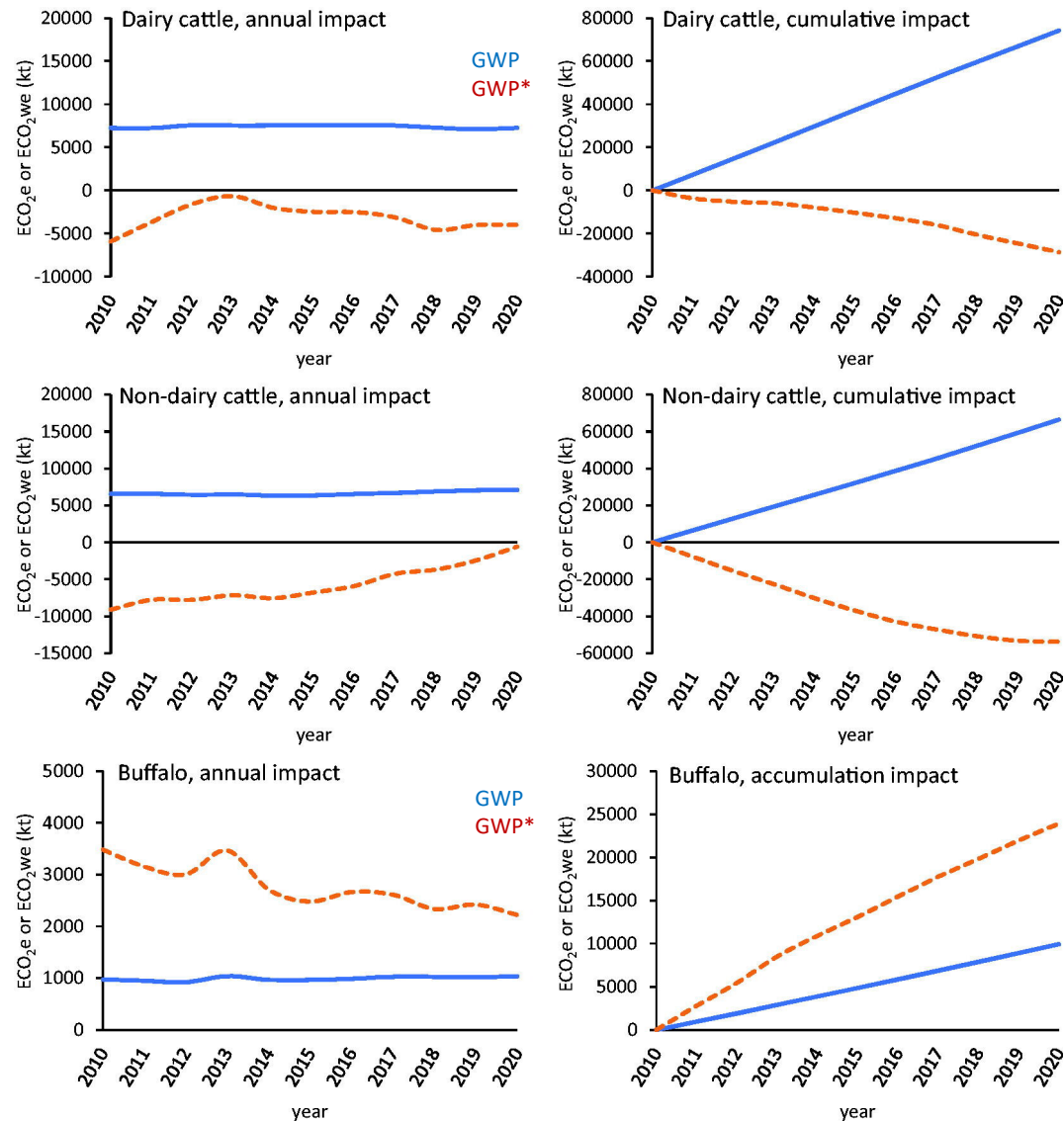
## Rethinking methane from animal agriculture

Shule Liu, Joe Proudman and Frank M. Mitloehner\*



## Climate impact of methane from US non dairy and dairy cattle production



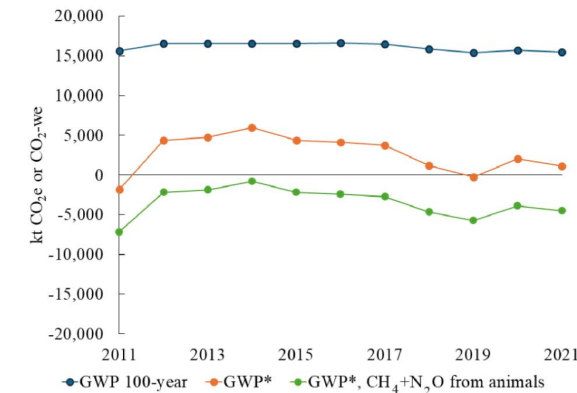


## Thirty years of global warming potential evolution for the Italian dairy cow sector measured by two different metrics

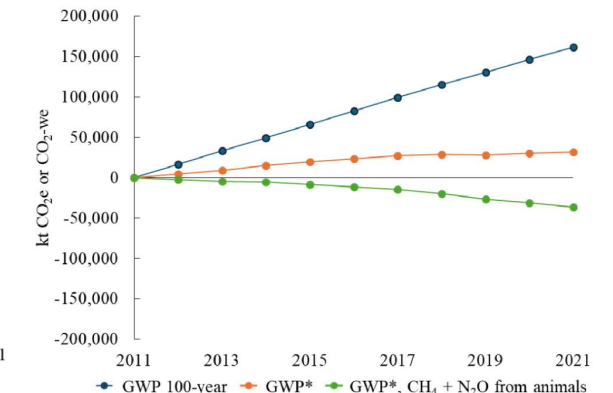
Marco Berton , Giovanni Bittante , Enrico Sturaro , and Luigi Gallo 

Dipartimento di Agronomia, Animali, Alimenti, Risorse naturali e Ambiente, University of Padova, Legnaro, Italy

A) annual rate of emission



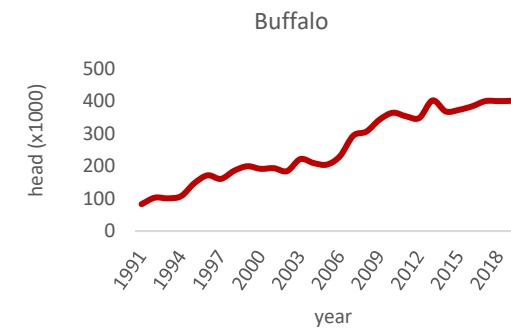
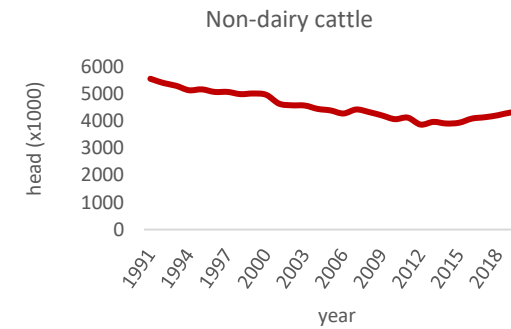
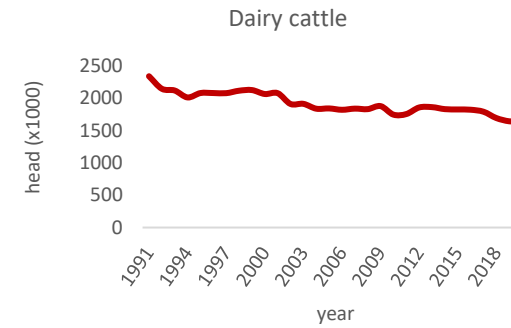
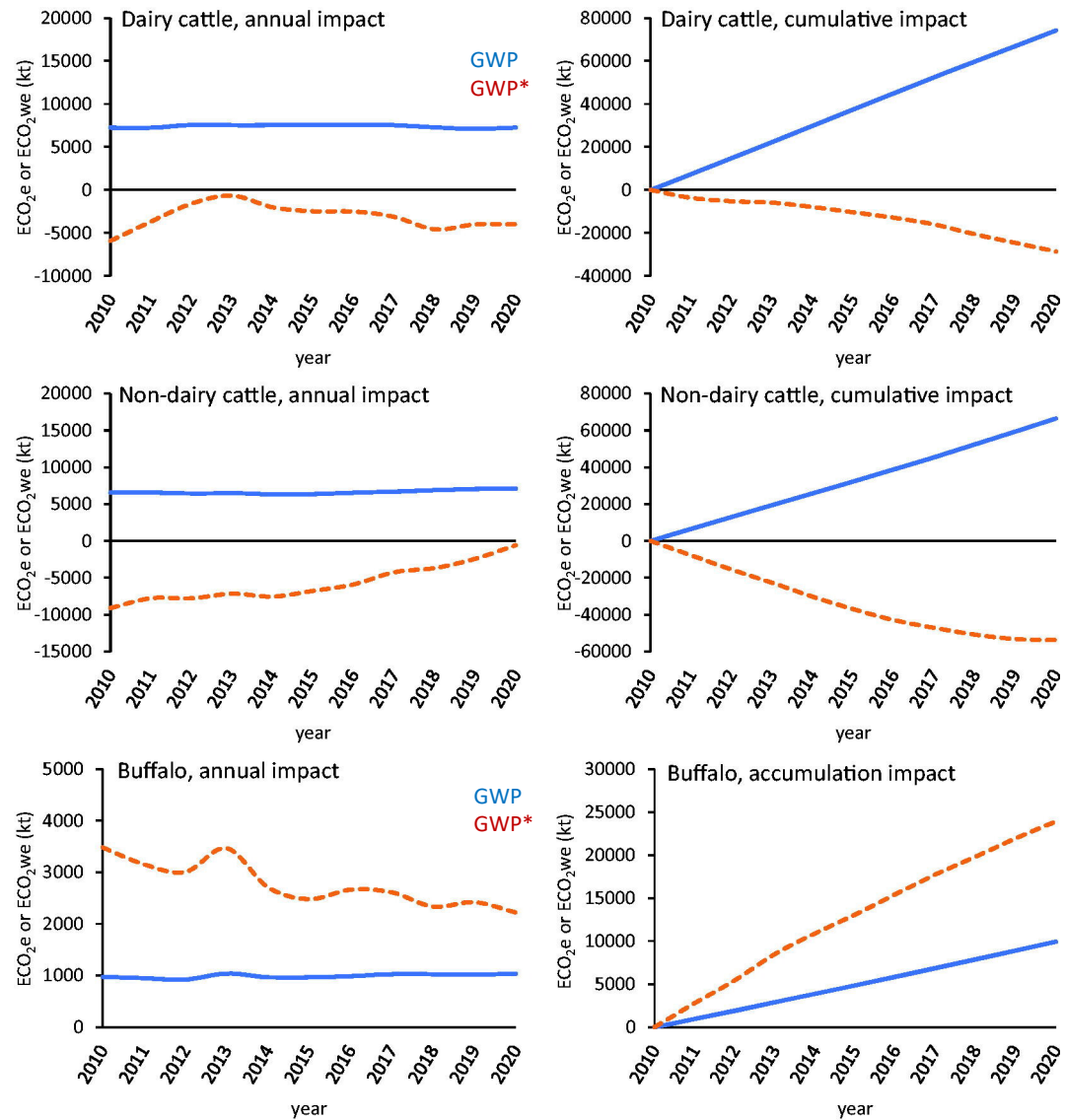
B) Cumulative emission from 2011 to 2021

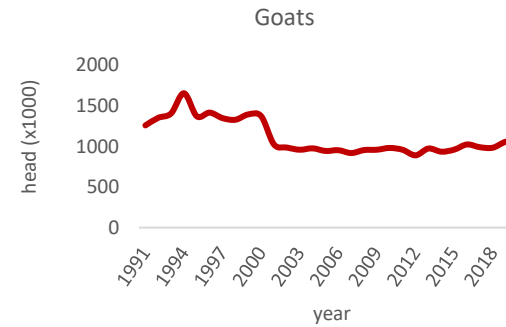
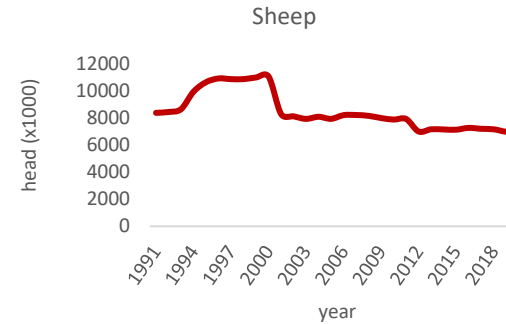
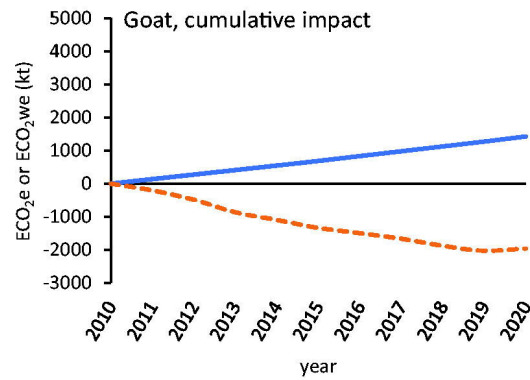
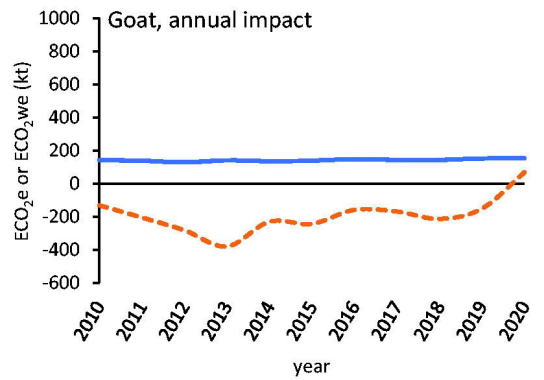
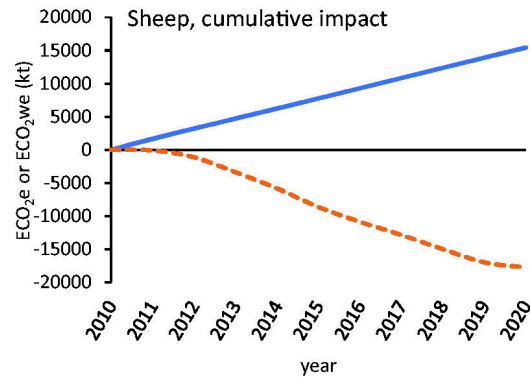
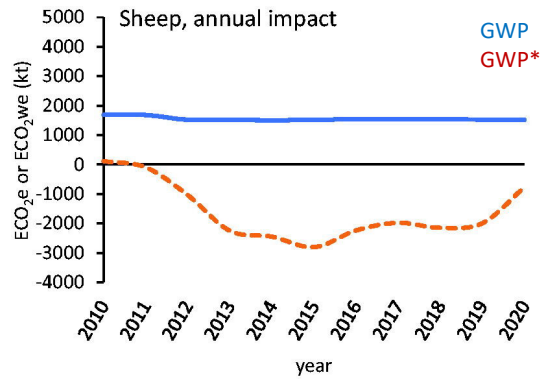


Annual rate and cumulative emission of GWP100 and GWP\* computed for the Italian dairy cattle sector in the 2011-2021 period.

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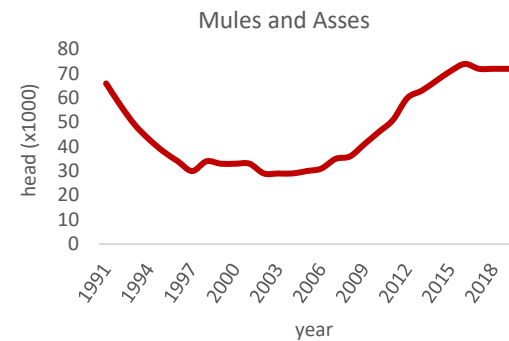
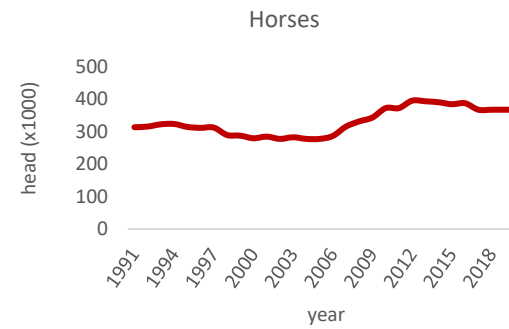
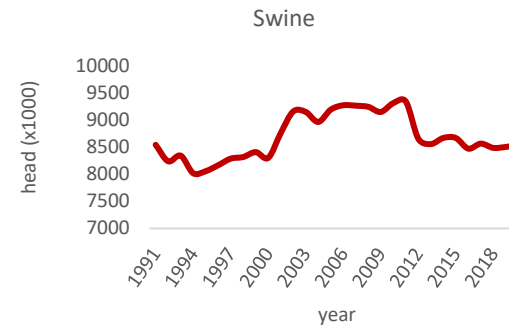
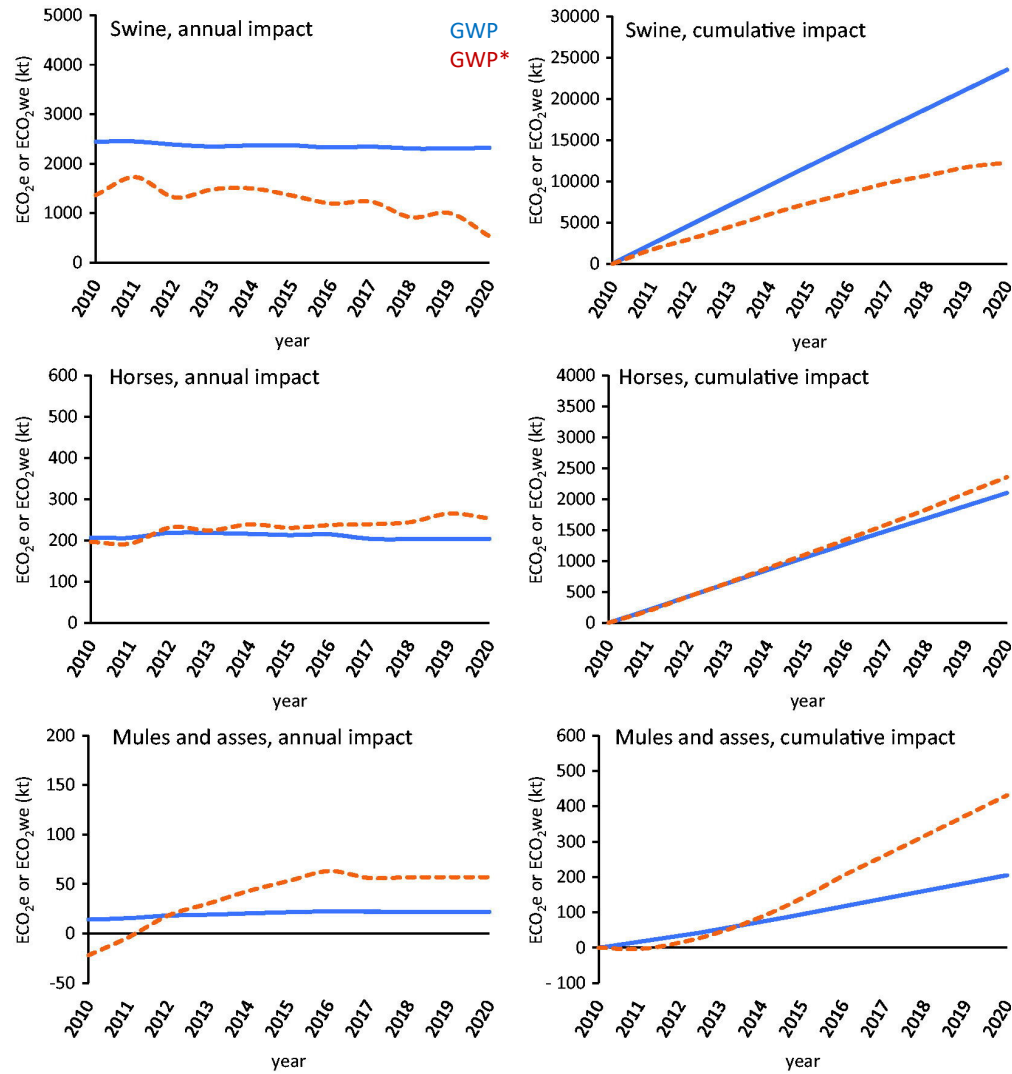
## RESULTS

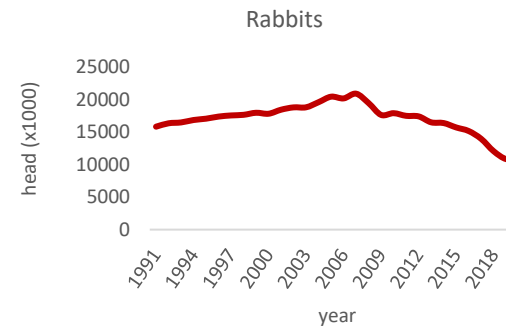
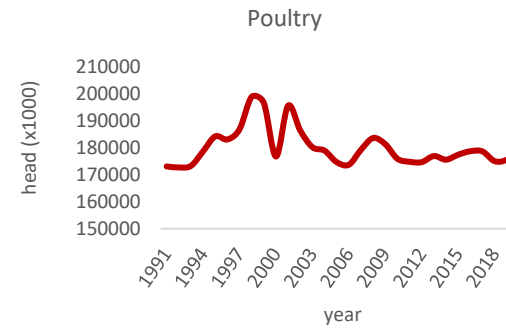
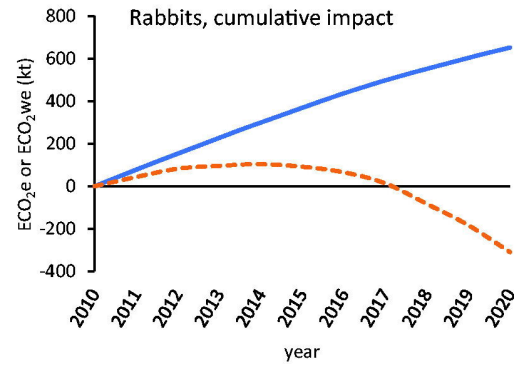
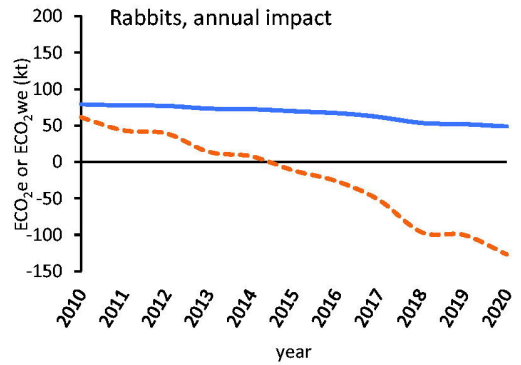
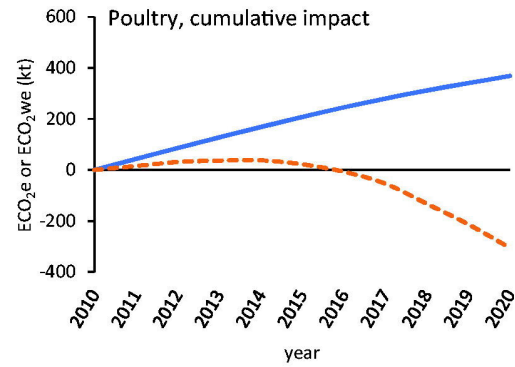
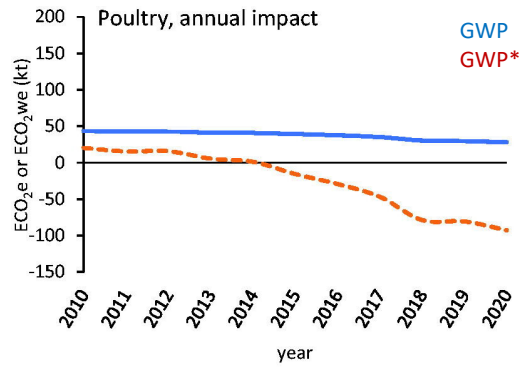




Using GWP\* to assess the GHG livestock emission impact:  
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# RESULTS





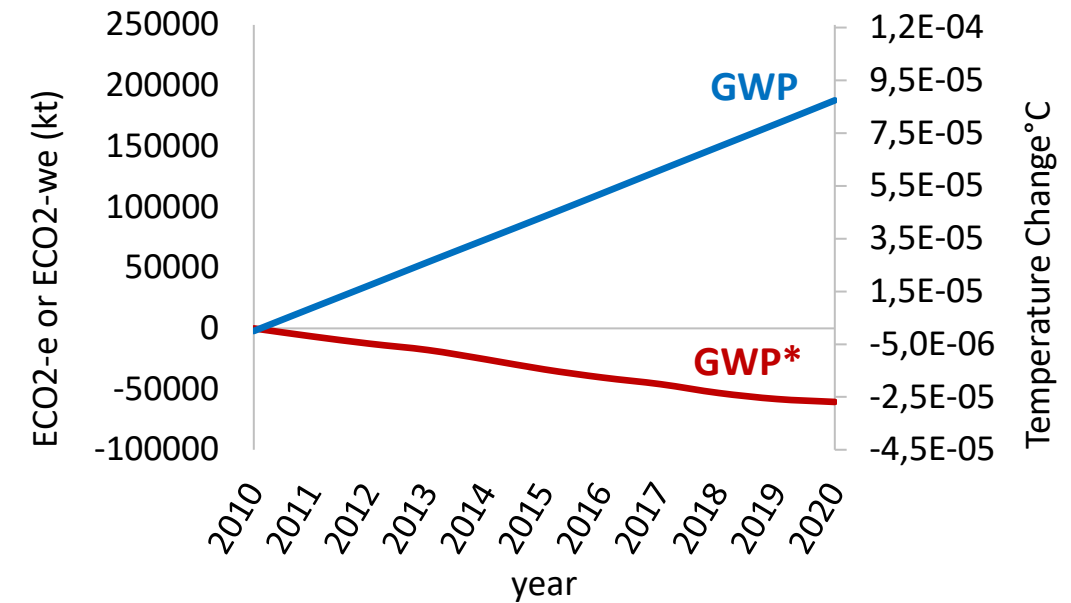
| Species                | CH <sub>4</sub> 1991<br>(kt) | CH <sub>4</sub> 2020<br>(kt) | Total<br>variation<br>(%) | Annual<br>average<br>variation<br>(%) | Cumulative<br>GWP 2010-<br>2020<br>(kt CO <sub>2</sub> e) | Cumulative<br>GWP* 2010-<br>2020<br>(kt CO <sub>2</sub> we) |
|------------------------|------------------------------|------------------------------|---------------------------|---------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------|
| Dairy cattle           | 325.2                        | 259.1                        | -20.3                     | -0.7                                  | 74,159                                                    | <b>-28,610</b>                                              |
| Non-dairy cattle       | 325.5                        | 252.8                        | -22.3                     | -0.8                                  | 66,437                                                    | <b>-53,786</b>                                              |
| Buffalo                | 7.8                          | 36.9                         | 372.2                     | 5.9                                   | 9,933                                                     | 27,073                                                      |
| Sheep                  | 63.3                         | 54.4                         | -14.1                     | -0.4                                  | 15,427                                                    | <b>-17,763</b>                                              |
| Goats                  | 6.5                          | 5.5                          | -15.5                     | -0.3                                  | 1,427                                                     | <b>-1,962</b>                                               |
| Swine                  | 81.6                         | 82.9                         | 1.6                       | 0.1                                   | 23,530                                                    | 12,266                                                      |
| Horses                 | 6.2                          | 7.3                          | 17.3                      | 0.6                                   | 2,100                                                     | 2,356                                                       |
| Mules and Asses        | 0.7                          | 0.8                          | 8.8                       | 0.7                                   | 205                                                       | 431                                                         |
| Poultry                | 1.5                          | 1.0                          | -32.7                     | -1.3                                  | 369                                                       | -306                                                        |
| Rabbits                | 2.5                          | 1.7                          | -30.7                     | -1.2                                  | 653                                                       | -310                                                        |
| <b>Total Livestock</b> | <b>820.9</b>                 | <b>702.4</b>                 | <b>-14.4</b>              | <b>-0.5</b>                           | <b>194,240</b>                                            | <b>-60,610</b>                                              |

| Species          | CH <sub>4</sub> 1991<br>(kt) | CH <sub>4</sub> 2020<br>(kt) | Total<br>variation<br>(%) | Annual<br>average<br>variation<br>(%) | Cumulative<br>GWP 2010-<br>2020<br>(kt CO <sub>2</sub> e) | Cumulative<br>GWP* 2010-<br>2020<br>(kt CO <sub>2</sub> we) |
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| Total Livestock  | 820.9                        | 702.4                        | -14.4                     | -0.5                                  | 194,240                                                   | -60,610                                                     |

### Cumulative impact of italian livestock



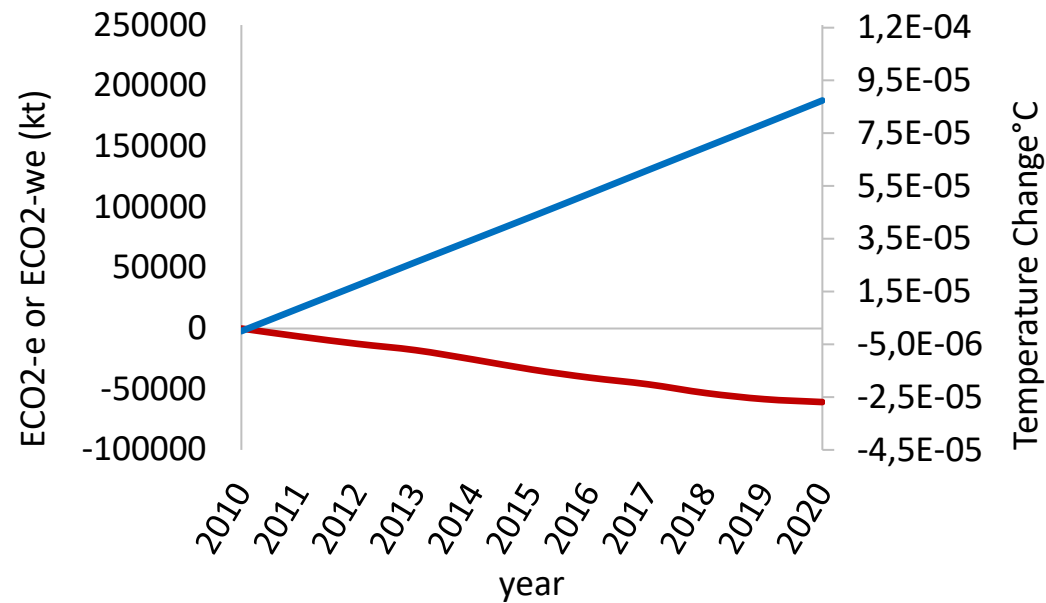
### Transient Climate Response to cumulative carbon Emission (TCRE)

Temperature change = 0.45°C per cumulative Tt CO<sub>2</sub> or CO<sub>2</sub>e

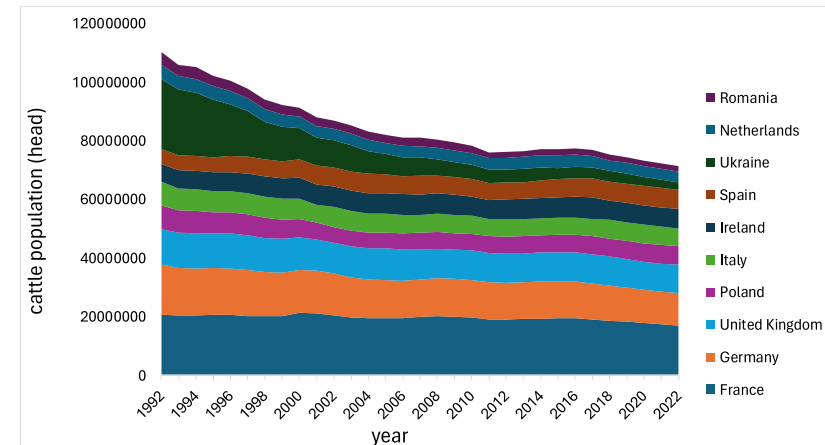
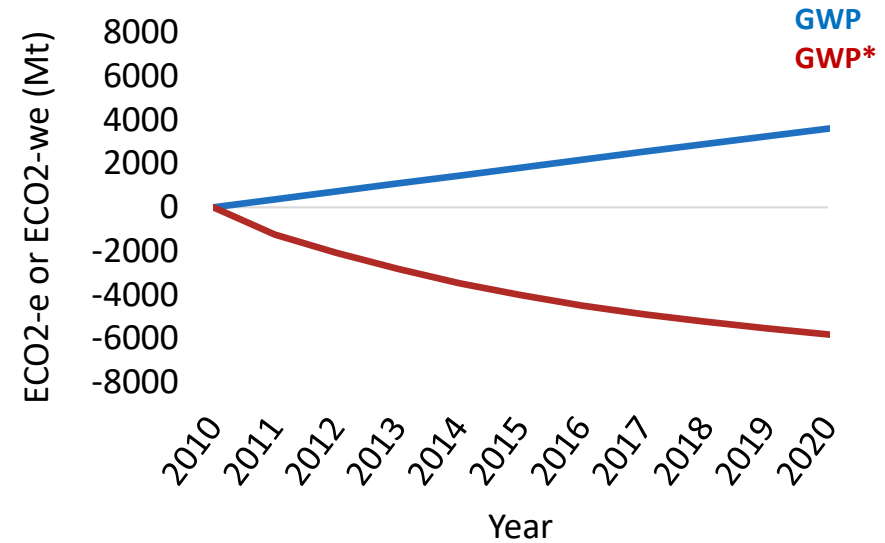
IPCC (2021)



### Cumulative impact of italian livestock

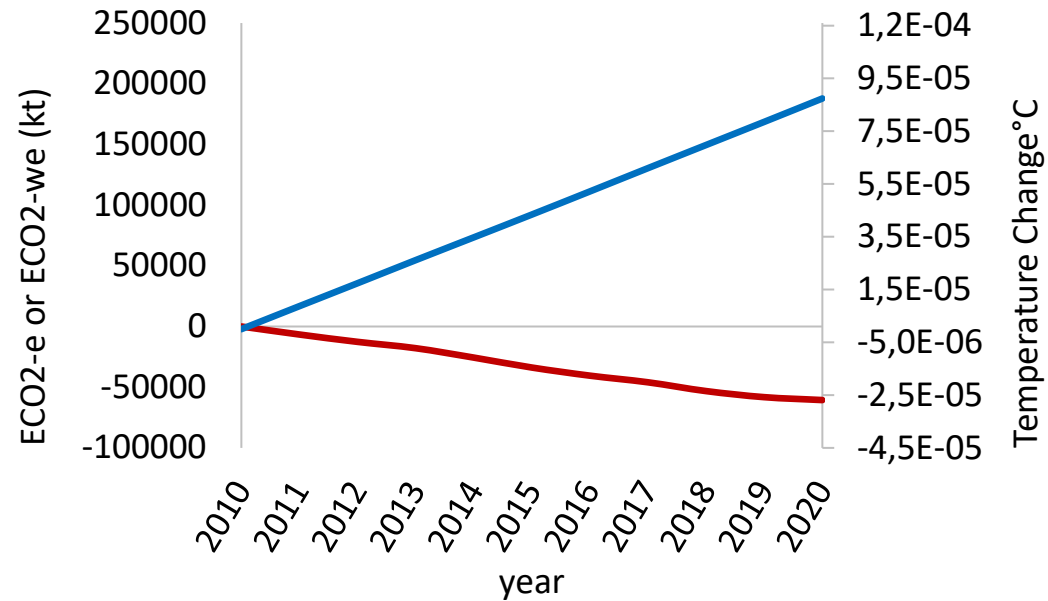


### Cumulative impact of European livestock

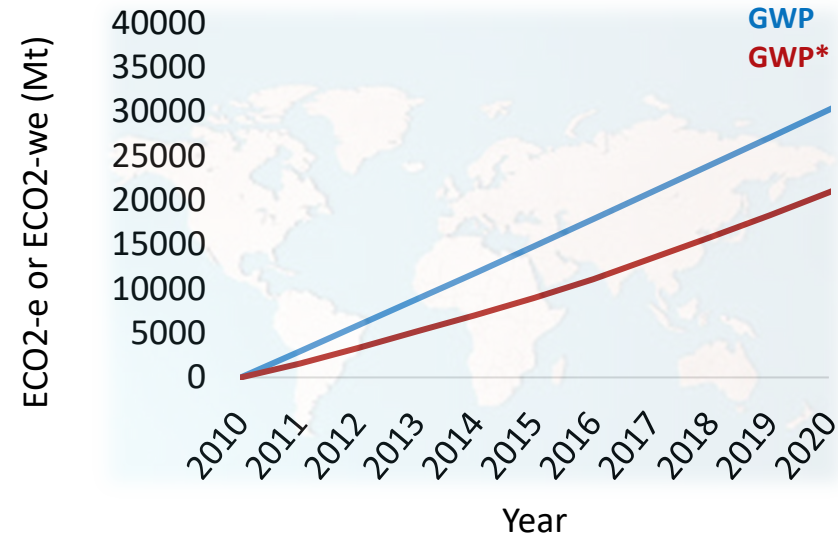




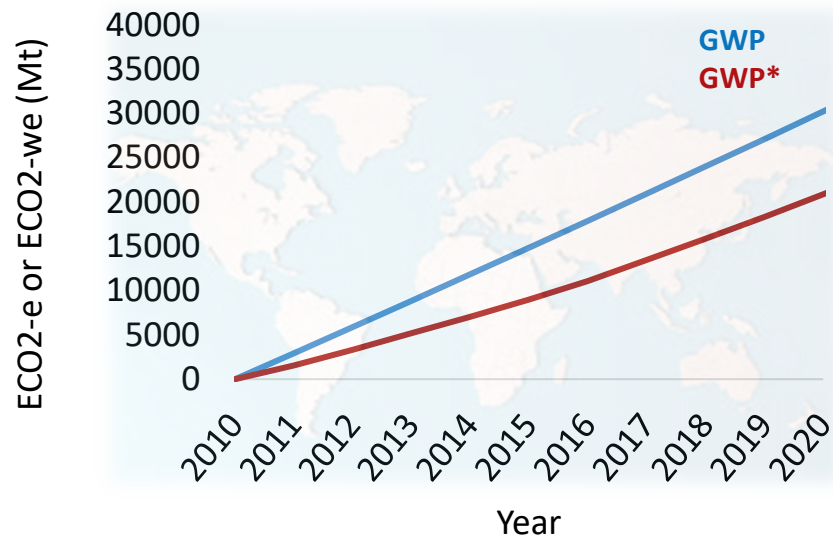
### Cumulative impact of italian livestock



### Cumulative impact of global livestock



## Cumulative impact of global livestock

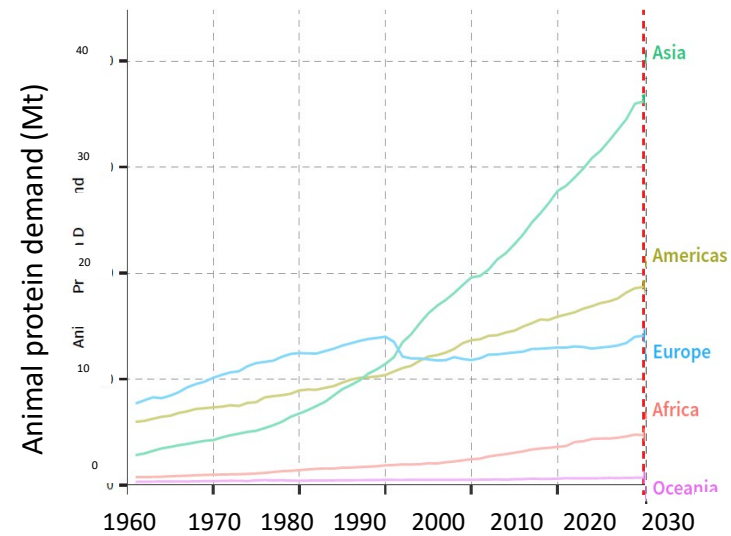


## Increase of cattle population in the last 40 years:

- Africa + 114%
- Asia + 32%
- South America + 56%

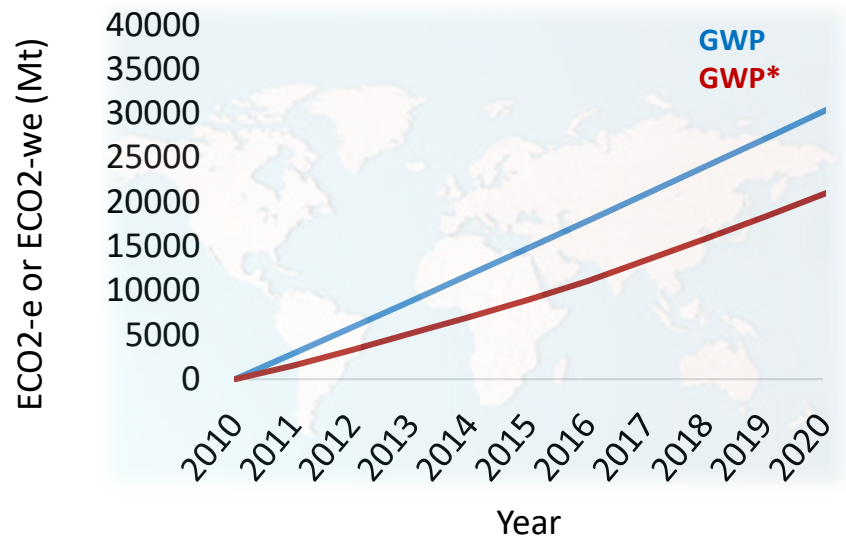


## Increase of animal protein demand



FAO. 2023. Pathways towards lower emissions

## Cumulative impact of global livestock

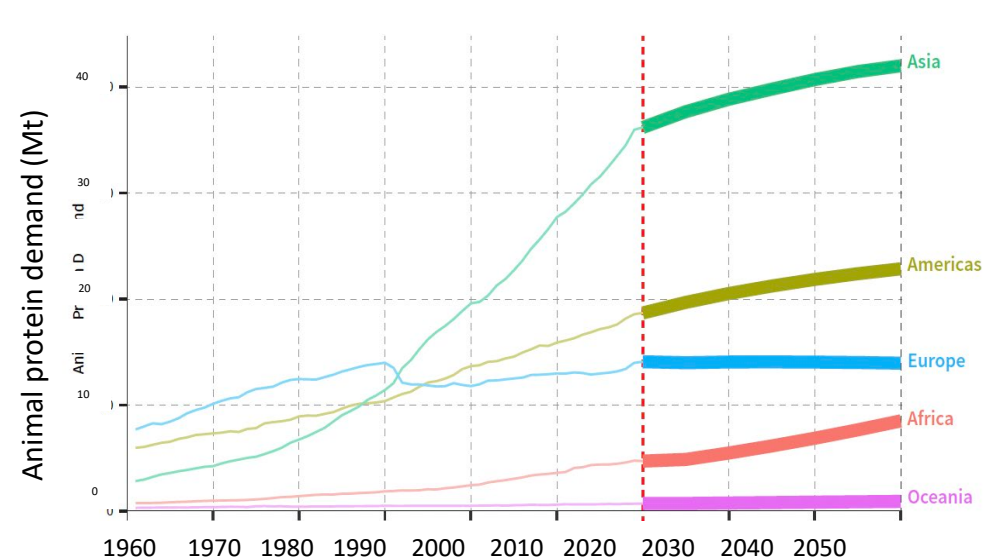


## Increase of cattle population in the last 40 years:

- Africa + 114%
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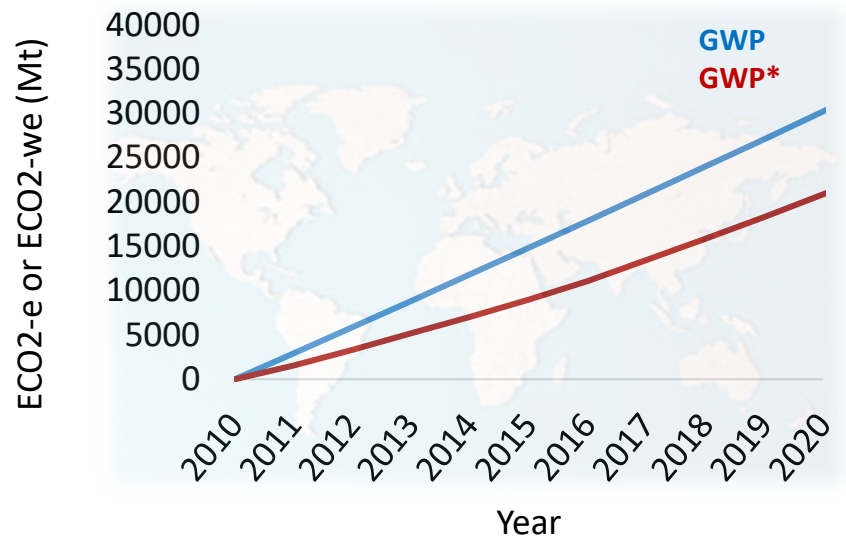
## Increase of animal protein demand... still growing



FAO. 2023. Pathways towards lower emissions

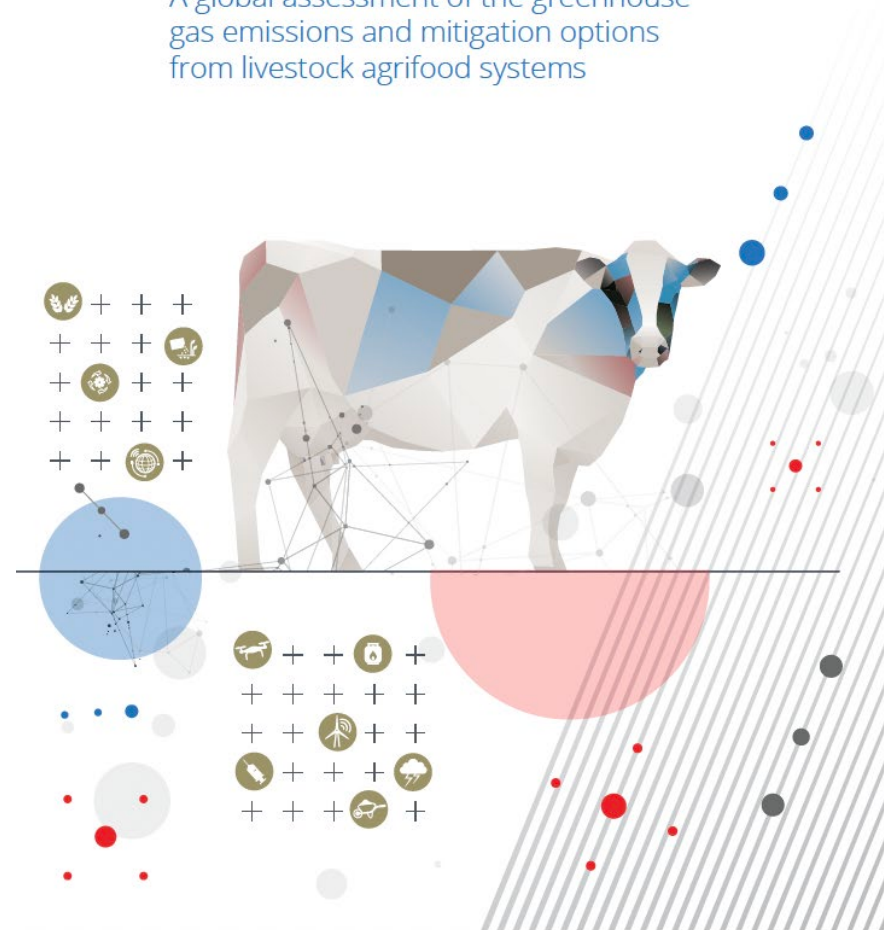


## Cumulative impact of global livestock

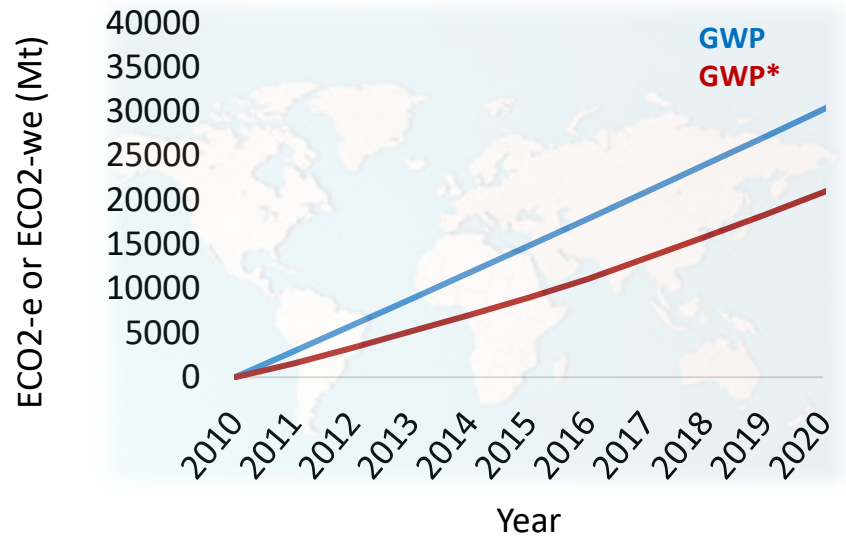


## Pathways towards lower emissions

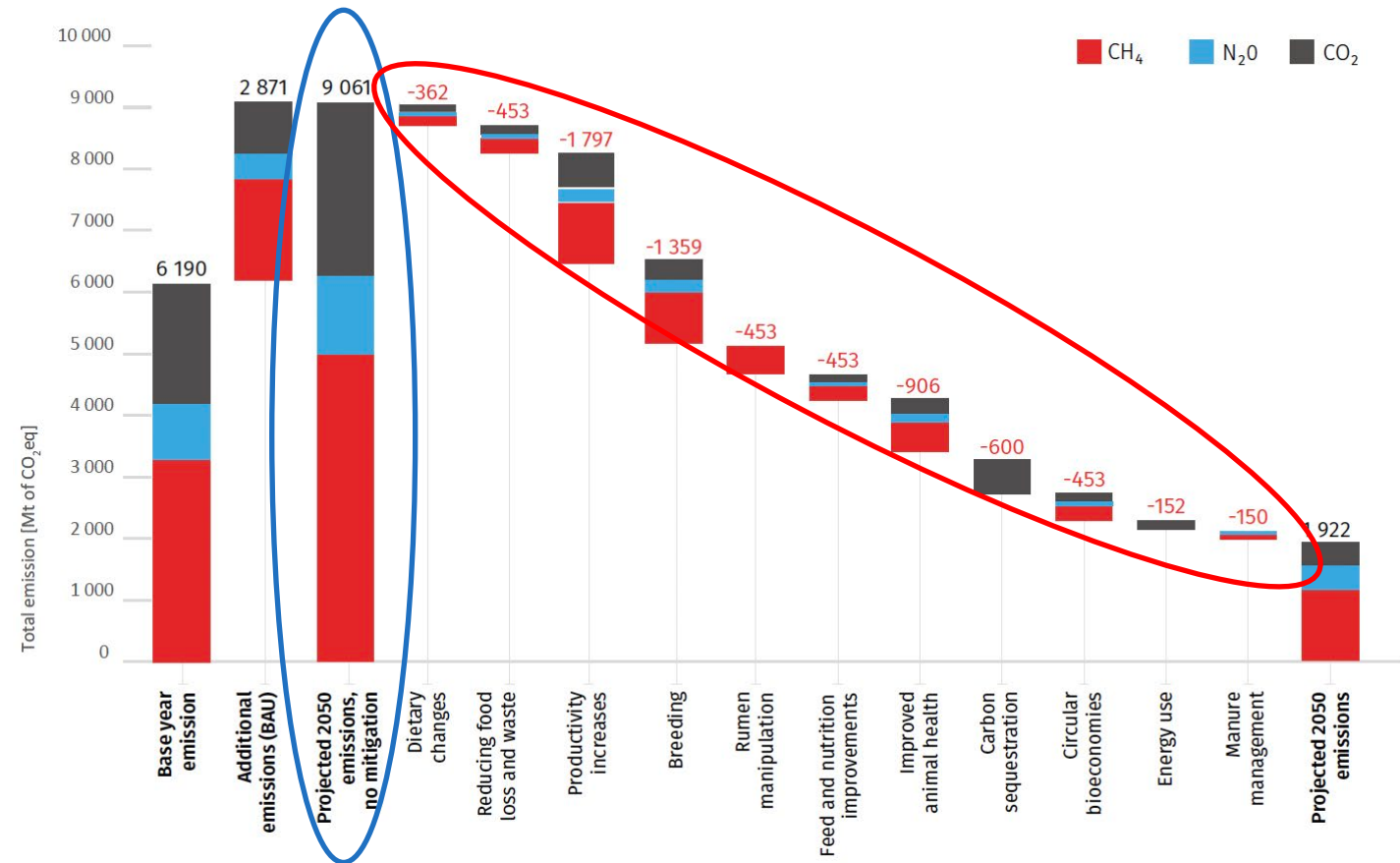
A global assessment of the greenhouse  
gas emissions and mitigation options  
from livestock agrifood systems



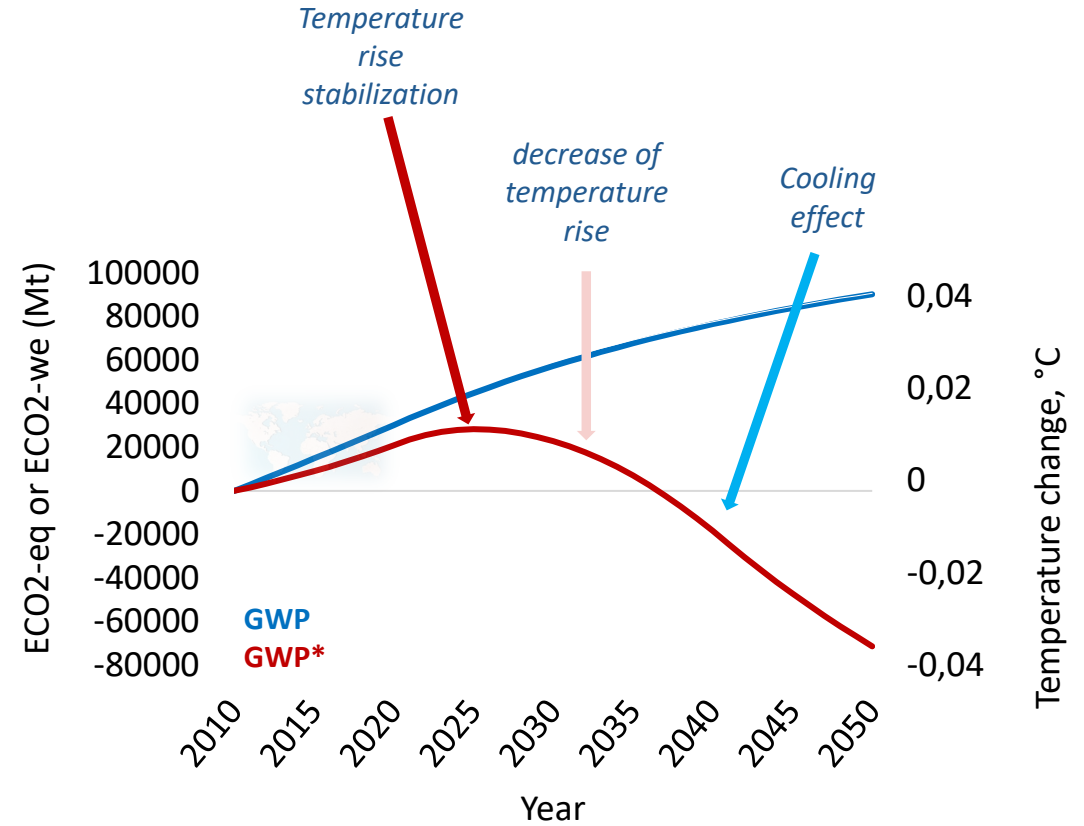
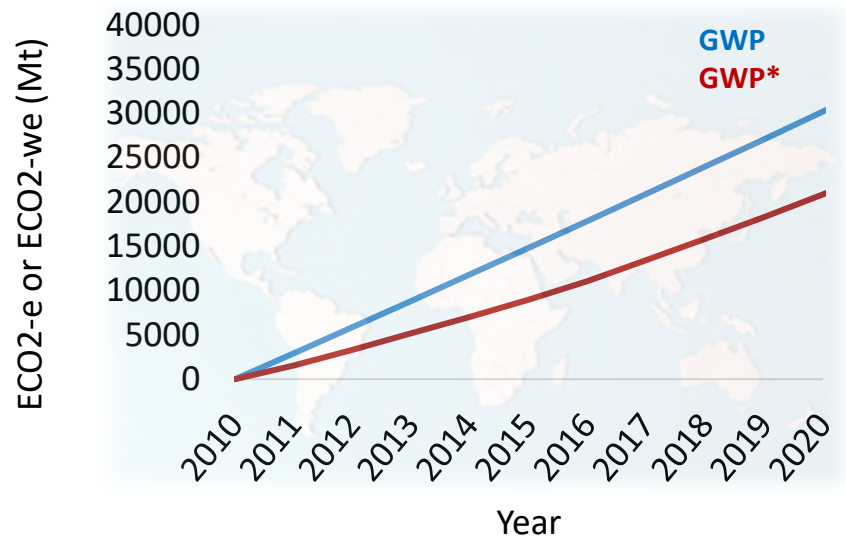
## Cumulative impact of global livestock



## Lower emissions scenario based on the potential percentage reduction of different intervention strategies



## Cumulative impact of global livestock



## Conclusions

- GWP\* allows a better understanding of methane's role in livestock contribution to the climate change
- Italian animal supply chains reduced the warming impact of CH<sub>4</sub> emissions over 2010-2020 time frame
- Cattle and small ruminants balance the increase of emission of other species
- Europe shows a similar virtuous trend of impact reduction
- Application of mitigation strategies can help livestock to largely reduce its impact while ensuring an increased global supply of animal products



# Thank you for your attention



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