PROPOSTA

PER REDUIR LA PETJADA ECOLÒGICA DE LA UPF DE FORMA DRÀSTICA, ÈTICA i INNOVADORA

RESUM:

- Responent a la reflexió que el rectorat de la UPF està fent en el marc de la iniciativa **Planetary Wellbeing** i la necessitat de prendre decisions radicals i efectives en coherència amb la **Declaració d'emergència climàtica**, l'UPF-Centre for Animal Ethics (CAE) suggereix prendre mesures pioneres en matèria de dieta que combinen la reducció d'emissions, l'ètica i la innovació tecnològica.

- Podem reduir la petjada ecològica de la comunitat UPF per molts camins (disminuint els consums energètics institucionals i individuals, contractant només energia verda, reciclant més, emprant menys paper, reduint o eliminant l'ús de plàstics, promovent la recerca sostenible, reduint la mobilitat, etc.) però cap d'ells té sentit si no afrontem també, i sobretot, el que constitueix individualment i col·lectiva un dels majors impactes tres vegades al dia: la dieta.

- Actuar sobre la dieta de forma radical implica una reducció d'emissions ràpida i rellevant, una decisió amb un impacte ètic múltiple i lideratge de futur.

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1. REDUCCIÓ D'EMISSIONS

Al menys un terç de totes les emissions de gasos d'efecte hivernacle es deuen a la producció d'aliments[1]. I d'aquest terç, el principal contaminant prové de la producció d'aliments basats en animals. El canal de notícies de Nacions Unides reiterava el problema a finals del 2018 per enèsima vegada:

> According to the World Economic Forum, the beef and dairy industry is responsible for more greenhouse gas emissions than the world's biggest oil companies, with the combined emissions of the top meat and dairy companies exceeding those of highly industrialized nations such as Germany or the UK[2].

En les mateixes dates la UNEP, el programa ambiental de Nacions Unides, ens recordava les moltes conseqüències negatives de la producció de carn:

> Meat production contributes to the depletion of precious water resources – around 1,695 litres is needed to produce just one quarter-pounder burger – and according to the Yale School of Forestry, cattle ranching is the largest driver of deforestation in every Amazon nation, accounting for 80 per cent of total clearance. Raising animals takes up about 80 per cent of agricultural land, but only contributes to 18 per cent of the world's calories[3].

El nombre de publicacions que informen de l'impacte de l'actual dieta humana en el planeta és ja inabastable i no para de créixer (a l'annex incloem un recull). Avui sabem que el principal problema d'aquesta dieta és la proteïna animal. A nivell mediambiental això significa que la carn, el peix, els ous i els derivats làctics que els humans mengen són una de les principals causes –en alguns casos la principal– de desforestació, pèrdua de biodiversitat, contaminació i escassetat d'aigua i d'emissions de gasos d'efecte hivernacle si atenem als cicles productius complets.

Algunes de les moltes estimacions documentades que s'han publicat al respecte inclouen:

- Canviar a una dieta vegetariana als països industrialitzats pot reduir la petjada hídrica de la gent en un 36%[4].
- La dieta omnívora emet el doble d'emissions de gasos d'efecte hivernacle que una dieta sense aliments d'origen animal[5].
- Una adopció amplia de la dieta vegetariana reduiria les emissions en un 63% i l'adopció d'una dieta vegana les reduiria en un 70%[6].
- Una reducció del 50% del consum de carn, lactis i ous a la Unió Europea suposaria una reducció per càpita del 40% de les emissions de nitrogen, del 25-40% de les emissions de gasos d'efecte hivernacle i del 23% de la terra emprada per a conreus a Europa[7].
- Consumir llet de soja emet 12 vegades menys emissions de CO_2 i necessita 3,5 vegades menys litres d'aigua que consumir llet de vaca[8].
- Per reduir a la meitat les emissions globals de gasos d'efecte hivernacle a nivell global és necessari menjar un 75% menys de carn de vaca, un 90% menys de carn de porc i la meitat d'ous. En els països industrials la reducció ha de ser superior: cal menjar un 90% menys de carn de vaca i un 60% menys de lactis[9].
- El pas a una dieta que exclou els productes animals té un potencial transformador: redueix l'ús de la terra per aliments en 3,1 milions d'hectàrees (una reducció del 76%), incloent una reducció del 19% en les terres de cultiu; redueix les emissions d'efectes de gasos hivernacle en 6,6 milions de tones de CO2eq anuals (una reducció del 49%); redueix l'acidificació en un 50%; redueix l'eutrofització en un 49% ; i redueix el problema d'escassetat d'aigua potable en un 19%[10].

Cal remarcar que els canvis d'un tipus de proteïna animal a un altre no solucionen el problema i en alguns casos l'empitjoren (l'enorme impacte ambiental de les piscifactories per exemple[11]) com tampoc el soluciona una agricultura no industrial o extensiva, que manté enormes problemes mediambientals (desforestació i erosió principalment)[12].

2. IMPACTE ÈTIC

Abandonar els productes d'origen animal a la dieta té a més tres enormes impactes de caràcter ètic.

El primer té a veure amb l'ètica animal, i més en concret amb el patiment i violència que la dieta omnívora causa i exerceix sobre desenes de milers de milions d'animals d'altres espècies. Les xifres d'animals explotats per la indústria de l'agricultura animal cada any són d'una magnitud inversemblant. Es calcula que anualment es lleva la vida d'uns 90.000 milions d'animals en granges terrestres i d'entre 1 i 3 bilions a través de la pesca o en piscifactories[13]. A les granges terrestres, el nombre d'animals que es manté confinats anualment és no obstant superior a la xifra d'animals que es porten a l'escorxador, donat que a la majoria els matem quan encara són infants o adolescents (per exemple entre els 3 i els 6 mesos en el cas dels vedells). La vida que obliguem a viure als animals explotats està documentada abastament[14] i és èticament injustificable[15]. Les alternatives d'explotació anomenades "humanes" només alteren aquestes condicions molt parcialment i de forma totalment insuficient[16].

Abandonar els productes d'origen animal a la dieta també té un impacte ètic en la mesura que suposa un efecte directe sobre la salut dels humans i en la despesa sanitària. La carn vermella i processada ha estat incorporada a la llista de productes que poden causar càncer que publica la Organització Mundial de la Salud[17], l'enorme ús que es fa d'antibiòtics a les granges té efectes directes sobre els humans[18], són àmpliament coneguts els negatius efectes de la carn a nivell cardiovascular[19], entre d'altres problemes de salut causats per les dietes basades en proteïna animal[20] (inclòs el fet no menor que suposen un consum permanent de micro-plàstics[21]). Una recerca d'investigadors de la Oxford Martin School ha estimat que la transició a dietes basades en plantes podria reduir la mortalitat humana entre un 6 i un 10% a tot el món i estalviar uns 31 bilions de dòlars (entre danys mediambientals, despesa mèdica, temps laboral perdut i morts prematures)[22] d'aquí al 2050.

Finalment, la violència que exercim contra les altres espècies –per causa de la dieta o per d'altres motius– està estretament vinculada amb la violència present a les societats humanes entre humans. S'han documentat abastament els profunds vincles existents entre la violència contra els animals i l'esclavatge humà[23], la violència masclista[24], la violència infantil[25], la violència econòmica[26], els desordres mentals[27], la criminalitat[28] o la pobresa alimentària[29], entre d'altres. És important recordar que l'accés a recursos (com la terra i l'aigua, en el cas de l'agricultura animal) ha estat històricament font recurrent de conflictes bèl·lics[30] i que el canvi climàtic, causat en gran part per les dietes basades en proteïna animal tant intensives en recursos, és causa de desplaçaments forçats com ja ha reconegut Nacions Unides pels migrants climàtics[31].

3. INNOVACIÓ TECNOLÒGICA

La carn de laboratori (creada artificialment a partir de cultius cel·lulars) és considerada habitualment el desenvolupament tecnològic més important per substituir l'agricultura animal. Tanmateix per ara aquesta biotecnologia no és ni ecològica ni ètica. Si bé, en comparació a l'agricultura animal, la carn in vitro requereix quantitats molt menors d'inputs agrícoles i de terra, aquests beneficis es fan a expenses de consums energètics molt més alts necessaris per replicar tots els processos biològics que tenen lloc en un cos viu per arribar a produir teixit muscular[32]. De manera que una producció a gran escala de carn de laboratori podria representar simplement una nova fase d'industrialització, amb contrapartides mediambientals importants[33]. La salut humana també queda compromesa, per alguns, amb aquesta biotecnologia. A més, la dependència del sèrum boví com a mitjà de cultiu impedeix, per les característiques de l'extracció, considerar la carn de laboratori lliure de crueltat animal. A hores d'ara ja hi ha empreses invertint en opcions de carn de laboratori realment lliures de crueltat[34], però es manté la incògnita del consum energètic si s'assoleix una producció industrial. Per aquest motiu, la substitució de carn amb opcions basades en plantes té avantatges molt més clares per l'absència confirmada en el seu cas de consums energètics alts i crueltat animal.

No és casualitat doncs que, al 2018, Nacions Unides hagi atorgat el seu màxim guardó per la protecció del medi ambient –el premi 2018 Champions of the Earth for Science and Innovation– a dues empreses de tecnologia alimentaria punta dedicades al desenvolupament de *carn* basada en plantes: les nord-americanes Beyond Meat (https://www.beyondmeat.com/) i Impossible Foods (https://impossiblefoods.com/)[35].

Beyond Meat i Impossible Foods produeixen alternatives sostenibles i ètiques a la carn i han estat qualificades per Nacions Unides com empreses revolucionàries pel caràcter pioner de la seva recerca tecno-alimentària. De la ma de científics dels camps de la biologia, la química, la geofísica i la ciència de les plantes i els aliments, així com d'enginyers, les dues empreses es dediquen a reproduir amb ingredients procedents de les plantes (com els pèsols, la remolatxa, l'oli de coco o el midó de patata) el que consideren és l'essència de la carn, els nutrients de les plantes convertits en energia. Només que aquestes empreses ho fan saltant-se els animals. El conseller executiu de Beyond Meat ho explica així:

> At a high level, meat is composed of amino acids, water, lipids, trace minerals and water. Animals use their digestive and muscular systems to convert vegetation and water into meat. We're going straight to the plant, bypassing the animal, and building meat directly, with the added benefit of being more sustainable. We get better every year and are on a relentless march toward that perfect and indistinguishable build of meat from plants.

Beyond Meat, en concret, no es redueix a investigar per substituir la carn amb el que ells anomenen és "la millor carn possible", les plantes, sinó que, al contrari del que fa la indústria agroalimentària global, estudien en paral·lel les emissions que produeixen en tot moment. Amb la Universitat de Michigan han arribat a la conclusió que menjar tres de les seves hamburgueses, enlloc d'hamburgueses de carn tradicional, a la setmana estalvia emissions de gasos d'efecte hivernacle equivalents a les emissions de 12 milions de cotxes. Això és així perquè les seves hamburgueses utilitzen un 99% menys d'aigua, un 93% menys de terra i generen un 90% menys d'emissions perjudicials comparades amb les de carn tradicional[36].

Aquests dos exemples no són els únics als Estats Units ni a la resta del món –a Europa també hi ha un nombre creixent d'empreses pioneres en la recerca i desenvolupament de *carn* de plantes, com la catalana Food for Tomorrow (https://foodsfortomorrow.com/ca/portada-3/) que produeix la marca Heura. Tots ells ens donen les claus del futur de transició que s'apropa ràpidament i que, com diu el cap del Programa de Nacions Unides pel Medi Ambient, Erik Solheim, demostren que l'acció climàtica positiva "pot ser deliciosa" i "no implica haver de fer sacrificis gastronòmics"[37].

4. PROPOSTES

El que proposem aquí és situar a la UPF en una posició de lideratge en el camí de transició a una alimentació basada en plantes i sense agricultura animal. Per aquest fi es proposa promoure accions tant a nivell institucional, com de recerca i docència que converteixin la UPF en pionera d'un canvi que comporta avantatges climàtiques, ètiques i de lideratge.

NIVELL INSTITUCIONAL	
Proposta	**Què s'aconsegueix**
- Garantir que a les cafeteries de la UPF el 50% de les opcions que s'ofereixin en tot moment siguin d'origen vegetal (tant en menús com en snacks, esmorzars, etc.).	Reducció del 25% de les emissions: Reducció automàtica en aproximadament un 25% de la petjada ecològica de la UPF a les cafeteries.
- Formar i estimular als cuiners de les cafeteries de la UPF en la transició alimentària cap a una alimentació basada en plantes.	Transició deliciosa i saludable: Aconseguir que les opcions vegetals siguin atractives, bones i saludables.
- Encarregar tots els càterings institucionals amb opcions 100% basades en plantes.	Reducció del 50% de les emissions: Reducció automàtica aproximadament a la meitat de la petjada ecològica dels càterings institucionals. Foment extern: es normalitzen les dietes totalment vegetals entre els proveïdors.
- Recomanar a la comunitat UPF que encarregui els seus càterings amb al menys un 50% d'opcions d'origen estrictament vegetal.	Reducció del 25% d'emissions: Reducció automàtica en aproximadament un 25% de la petjada ecològica dels càterings no institucionals a la UPF.
- Fomentar la contractació externa d'empreses 100% veganes i/o pioneres en transició alimentària cap a un model sense agricultura animal.	Foment extern: es recolza a les empreses que ja han iniciat la transició. Foment intern: es donen a conèixer els darrers avenços en alimentació basada en plantes a la comunitat UPF.
- Demanar que tots els serveis de restauració dels campus portin un control estricte del tipus i quantitat de menjar que s'acaba tirant.	Identificar malbaratataments: Sovint s'han d'acabar tirant productes alimentaris d'origen animal mentre que les opcions basades en plantes, molt més sostenibles, s'esgoten o no són suficients. Portar un control d'això permetrà ajustar encara més la reducció de proteïna animal dels menús.

NIVELL DOCÈNCIA I RECERCA
- Incorporar de forma transversal a grau i màsters l'impacte de la dieta omnívora en el medi ambient
- Crear una assignatura transversal de màster sobre ètica animal, no especista i interespècie per estudiar les interaccions entre totes les violències estructurals, inclosa la mediambiental
- Fomentar la recerca que promogui la transició alimentària cap a un model sense agricultura animal
- Establir acords de cooperació amb empreses de biotecnologia alimentària basada en plantes

La UPF pot acompanyar les actuacions anteriors amb una estratègia de comunicació interna i externa que faci pedagogia del triangle d'avantatges, normalitzi la dieta sostenible i acompanyi, formi i encoratgi cap a la transició alimentària.

El Centre d'Ètica Animal s'ofereix a col·laborar en les accions relacionades, per exemple aportant experts en nutrició i alimentació de transició cap a una alimentació basada en plantes que assessorin a la restauració, ajudant a contactar amb empreses pioneres en alimentació basada en plantes o amb experts.

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ANNEX: RECULL DE LITERATURA

Selecció de literatura rellevant sobre l'impacte de l'agricultura animal sobre l'escalfament global i algunes altres variables relacionades amb el medi ambient i el canvi climàtic.

1. Informes d'organitzacions governamentals
2. Informes d'ONGs i Think tanks
3. Articles publicats a revistes científiques
4. Llibres

1. INFORMES D'ORGANITZACIONS GOVERNAMENTALS

1. UNESCO, 2003 - **Chapagain, A.K. and Hoekstra, A.Y. (2003). Virtual water flows between nations in relation to trade in livestock and livestock products. Value of Water Research Report Series No.13, UNESCO-IHE.**
Although the bulk of food trade is in the form of cereals, the international virtual water flows related to trade in livestock and livestock products are quite significant (nearly half of the volume of virtual water flows related to crop trade). The reason for this is that the virtual water content of livestock products is very high compared to the virtual water content of cereal crops. A change in the diet of a nation could thus intensify or nullify virtual water imbalances. For example, if the Chinese people changed their diet to that of an average American, the virtual water balance of the Central and South Asia region, which is already a net importer of virtual water, would worsen severely. When undertaking this study, it soon became apparent that a shortage of data posed a serious problem which may be the reason why such quantifications have not been attempted thus far. This is only a first step forward in defining a logical methodology to calculate the virtual water flows in relation to the international trade in livestock products; refinement of the method and collection of more reliable data are possible and necessary.

2. World Bank, 2004 - **Margulis, S. (2004). *Causes of deforestation of the Brazilian Amazon*. Washington, D.C: World Bank.**
Land-use data on Amazonia demonstrates that the main cause of deforestation in the region is cattle ranching. Expansion of ranching since the early 1970s has been a continuous and inertial process.

3. FAO, 2006 - **Steinfeld, H., Food and Agriculture Organization of the United Nations., & Livestock, Environment and Development (Firm). (2006). *Livestock's long shadow: Environmental issues and options*. Rome: Food and Agriculture Organization of the United Nations.**
Animal agriculture is responsible for 18 percent of greenhouse gas emissions, more than the combined exhaust from all transportation. Livestock is responsible for 65% of all human-related emissions of nitrous oxide – a greenhouse gas with 296 times the global warming potential of carbon dioxide, and which stays in the atmosphere for 150 years. The livestock sector emerges as one of the top two or three most significant contributors to the most serious environmental problems.

4. IPCC, 2007 - **IPCC (2007). *Climate change 2007: Synthesis report*. [Core writing team: R K Pachauri; Andy Reisinger; Lenny Bernstein; Intergovernmental Panel on Climate Change]. IPCC, Geneva, Switzerland.**
It is very likely that the observed increase in CH4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N2O concentration is primarily due to agriculture. Share of different sectors in total anthropogenic GHG emissions in 2004 in terms

of CO2-eq. (Forestry includes deforestation): Agriculture (13.5%) and Forestry (17.4%): 30.9%

5. UNEP, 2010 **- UNEP (2010).** ***Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management*****. Hertwich, E., van der Voet, E., Suh, S., Tukker, A., Huijbregts M., Kazmierczyk, P., Lenzen, M., McNeely, J., Moriguchi, Y.**
   Agriculture and food consumption are identified as one of the most important drivers of environmental pressures, especially habitat change, climate change, water use and toxic emissions. One significant driver for ecosystem degradation has been the expansion of the human population and changes in diet. Substantial habitat losses have arisen due to increased demand for land for agriculture and grazing, and significant declines in game and fish populations have resulted from over- harvesting. Agriculture is also the most important user of land. According to the FAO database, about 38% of the total world's land area is used for agriculture and 70% of total water use (FAOSTAT resource database). Compared to industrial processes, agricultural processes have an inherently low efficiency of resource use, which renders food, fibers and fuels from agriculture among the more polluting resources. This is true especially for animal products, where the metabolism of the animals is the limiting factor. Large proportions of the world's crops are fed to animals and this is expected to increase to 40–50% of global cereal production in 2050 (Aiking et al. 2006). A substantial reduction of impacts would only be possible with a substantial worldwide diet change, away from animal products.

6. European Commission, 2010 - **Leip, A., Weiss, F., Wassenaar, T., Perez, I., Fellmann, T., Loudjani, P., Tubiello, F., Grandgirard, D., Monni, S. &, Biala, K. (2010):** ***Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS) –final report*****. European Commission, Joint Research Centre.**
   Total GHG fluxes of European livestock production including land use and land use change emissions from beef production (29%), from cow milk production (29%) and from pork production(25%)n, while all other animal products together do not account for more than 17% of total emissions. According to IPCC classifications, 49% of total emissions are created in the agricultural sector, 21% in the energy sector and 2% in the industrial sector. Total emissions of European livestock production amount to 9.1% of total GHG emissions estimated in the national GHG inventories (EEA, 2010) or 12.8% if land use and land use change emissions are included. This number is lower than the value estimated in the FAO report 'livestock's long shadow' (FAO, 2006) of 18%, but for this comparison it has to be kept in mind that (i) GGELS estimates are only related to the EU, FAO results to the whole world, (ii) CAPRI estimates generally by 21% lower GHG emissions from agricultural activities, (iii) no other sector in this comparison is estimated on a product basis, and (iv) post-farm gate emissions are not considered in GGELS. Uncertainties are high and could not be quantified in the present study.

7. UNESCO, 2010 - **Mekonnen, M.M. and Hoekstra, A.Y. (2010)** ***The green, blue and grey water footprint of farm animals and animal products*****. Value of Water Research Report Series No. 48, UNESCO-IHE, Delft, the Netherlands.**
   29% of the total water footprint of the agricultural sector in the world is related to the production of animal products. One third of the global water footprint of animal production is related to beef cattle. The global meat production has almost doubled in the period 1980-2004 (FAO, 2005) and this trend is likely to continue given the projected doubling of meat production in the period 2000-2050 (Steinfeld et al., 2006). To meet this rising demand for animal products, the on-going shift from traditional extensive and mixed farming to industrial farming systems is likely to continue. Because of the larger dependence on concentrate feed in industrial systems, this intensification of animal production systems will result in increasing blue and grey water footprints per unit of animal product. The pressure on the global freshwater resources will thus increase both because of the increasing meat consumption and the increasing blue and grey water footprint per unit of meat consumed. Managing the demand for animal products by promoting a dietary shift away from a meat-rich diet will be an inevitable component in the environmental policy of governments.

8. FAO, 2010 - **Gerber, P. (coord.) (2010). *Greenhouse gas emissions from the dairy sector. A life cycle assessment*. Food and Agriculture Organization of the United Nations, Rome, Italy.**
The overall global emissions attributed to the dairy herd, are estimated to contribute to 4.0 percent of total anthropogenic emissions [±26 percent]. This includes the production of milk, the processing of milk products, transport activities, the production of meat from dairy related animals (old stock and young fattened stock), as well as the provision of draught power. Methane is by far the largest contributor to total GHG emissions from the dairy sector - accounting for over half of total emissions, while nitrous oxide contributes to between 30 and 40 percent of total emissions. Livestock systems in the temperate regions, mainly in industrialized countries, were found to have much lower emissions per kg of milk and meat than systems in the arid and humid zones in the developing countries.

9. UNESCO, 2011 - **Gerbens-Leenes, P.W., Mekonnen, M.M. and Hoekstra, A.Y. (2011). *A comparative study on the water footprint of poultry, pork and beef in different countries and production systems*. Value of Water Research Report Series No. 55, UNESCO-IHE.**
Beef has a much larger water footprint than poultry and pork. However, the large use of concentrates in the feed of broilers in all systems and of pigs in industrial systems causes a relatively large blue and grey WF for poultry and pork, in several cases larger than for beef. Differences between countries indicate that there are possibilities to decrease water footprints of meat production by finding a proper balance between a low-WF feed composition and high feed conversion efficiency. The water footprint related to the consumption of animal products, globally 2,422 Gm3 or one third of the total water footprint of agriculture, can also decrease by replacing animal products by food products of plant origin, or by reducing food waste. The water footprint of meat is in general far greater than the water footprint of plant based sources of equivalent foods (Mekonnen and Hoekstra, 2010b). As shown by Hoekstra (2010), the food-related water footprint of a consumer in an industrialized country can be reduced by 36 per cent by shifting from an average meat-based diet to a vegetarian diet.

10. UNESCO, 2011 - **Ercin, A.E., Aldaya, M.M. and Hoekstra, A.Y. (2011). *The water footprint of soy milk and soy burger and equivalent animal products*. Value of Water Research Report Series No.49, UNESCO-IHE.**
The aim of this study is to compare the claims on freshwater resources of soy products versus equivalent animal products and to consider how the type of agricultural practice (organic versus non-organic; rainfed versus irrigated) can influence freshwater claims as well. Results show that the water footprints of soy milk and soy burger depend significantly on the locations of the farms producing the soybean and on the agricultural practices at these farms (organic vs. non- organic and rainfed vs. irrigated). For the limited number of cases that we have considered, we find that non-organic soybean has a larger water footprint (ranging between 2145-3172 m3/ton) than organic soybean (1520-2024 m3/ton). The study shows that soy milk and soy burger have much smaller water footprints than their equivalent animal products. The water footprint of the soy milk product analyzed in this study is 28% of the water footprint of the global average cow milk. The water footprint of the soy burger examined here is 7% of the water footprint of the average beef burger in the world.

11. UNEP, 2012 - **UNEP (2012). *Growing greenhouse gas emissions due to meat production*. UNEP Global Environmental Alert Service.**
This paper is a summary gathering the main sources. Estimates of the total emissions from agriculture differ according to the system boundaries used for calculations. Most studies attribute 10-35 per cent of all global GHG emissions to agriculture (Denman et al. 2007, EPA 2006, McMichael 2007, Stern 2006). Large differences are mainly based on the exclusion or inclusion of emissions due to deforestation and land use change. Recent estimates concerning animal agriculture's share of total global GHG emissions range mainly between 10-25 per cent (Steinfeld et al. 2006, Fiala 2008, UNEP 2009, Gill et al. 2010, Barclay 2012), where again the higher figure includes the effects of deforestation and other land use changes and the lower one does not. According to Steinfeld et al. (2006) and McMichael et al. (2007), emissions from livestock constitute nearly 80 per cent of all agricultural emissions.

12. UNEP , 2012 - **UNEP (2012) Avoiding future famines: Strengthening the ecological foundation of food security through sustainable food systems. United Nations Environment Programme, Nairobi, Kenya**

The first objective of this report is to explain the significance of the ecological foundation of food security, and how this foundation is being undermined by pressures from society. The second objective is to explain how to solve this dilemma by building sustainable food systems. It must also be noted that sustainable diet guidelines have potentially negative impacts including economic instability due to a reduction in the size of the food, drink and livestock industries; an increase in land use to meet demand in regions that normally depend on imported food; reduction in trade with developing countries; and infringement of regional trade rules on free movements goods (SDC, 2009). For example, in 2009 the food and environmental agencies of the Swedish Government submitted a proposal for an EU food consumption standard to the European Commission (NFA 2009). The document was withdrawn in 2011 when the agencies were notified that some of its contents (e.g. eating seasonally and locally probably infringed upon EU internal trade rules designated to facilitate free movement of goods.

13. FAO, 2013 - **Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations (FAO), Rome.**

We have known for several years that livestock supply chains are an important contributor to climate change. This new report shows that the potential to significantly reduce emissions exists and is within reach. This report identifies ways of reducing emissions by assessing the mitigation potential of sets of technologies. Such analysis provides guidance for local and system-specific solutions, as sector actors seek to improve sustainability and viability, but also for more targeted pro-poor livestock development. It is estimated that up to one-third of the livestock sector's emissions could be reduced in the short to medium term by the greater use of more efficient, readily available practices and technologies.

14. IPCC, 2014 - **IPCC, 2014: *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.**

Globally, economic and population growth continue to be the most important drivers of increases in CO2 emissions from fossil fuel combustion. Since 2000, GHG emissions have been growing in all sectors, except in agriculture, forestry and other land use (AFOLU). In 2010, 35% of GHG emissions were released by the energy sector, 24% (net emissions) from AFOLU, 21% by industry, 14% by transport and 6.4% by the building sector. When emissions from electricity and heat production are attributed to the sectors that use the final energy (i.e., indirect emissions), the shares of the industry and building sectors in global GHG emissions are increased to 31% and 19%, respectively. Reducing emissions of non-CO2 climate forcing agents can be an important element of mitigation strategies. Emissions of non-CO2 gases (methane (CH4), nitrous oxide (N2O), and fluorinated gases) contributed about 27% to the total emissions of Kyoto gases in 2010. For most non-CO2 gases, near-term, low-cost options are available to reduce their emissions. However, some sources of these non-CO2 gases are difficult to mitigate, such as N2O emissions from fertilizer use and CH4 emissions from livestock. Emissions can be substantially lowered through changes in consumption patterns, adoption of energy savings measures, dietary change and reduction in food wastes.

2. INFORMES D'ONGs I THINK TANKS

1. Worldwatch Institute. (2004). Now, it's not personal! *World Watch Magazine*, 17(4).

To provide an overview of just how central a challenge this once marginal issue has become, we decided to survey the relevance of meat-eating to each of the major categories of

environmental impact that have conventionally been regarded as critical to the sustain- ability of civilization.

2. **GEU/NGL (2007). The livestock industry and climate – EU makes bad worse is. The delegation of the Swedish Left Party in GUE/NGL. Written by Jens Holm and Tovio Jokkala**
   This report investigates the impact of the continually increasing consumption of meat on climate change, and the roll the EU plays in it. We also divulge how the Swedish government, on its home turf, gives the impression of working to abolish the hated export refund for meat products, while in Brussels giving its support for increases in the same. Over a third of all grain harvested becomes fodder. Is that rational? Why not produce less meat and raise fewer animals on food crops, thereby freeing grain for feeding more people and even have a surplus for biofuel?

3. **Greenpeace (2008). Cool Farming: Climate impacts of agriculture and mitigation potential. Written by: Jessica Bellarby, Bente Foereid, Astley Hastings And Pete Smith from the University Of Aberdeen.**
   Since meat production is inefficient in its delivery of products to the human food chain, and also produces large emissions of GHG, a reduction of meat consumption could greatly reduce agricultural GHG emissions. Taken together, these could change the position of agriculture from one of the largest greenhouse gas emitters to a much smaller GHG source or even a net carbon sink.

4. **FOE (2010). Healthy Planet Eating: How lower meat diets can save lives and the planet. Friends of the Earth.**
   The production of meat and dairy is one of the most significant contributors to climate change and global wildlife loss – yet little is being done to reduce its impact. To enable a shift to planet-friendly farming methods, we need to re-think the type and quantity of meat on our plates. FOE pretends to show how switching to diets that contain less and better quality meat could play a key role in improving the nation's health. It shows how we can save lives and the planet while continuing to enjoy meat and dairy.

5. **The Environmental Working Group (EWG) (2011): A Meat Eater's Guide to Climate Change + Health: What You Eat Matters. Written by By Kari Hamerschlag, EWG Senior Analyst.**
   Eating Less, Greener and Healthier Meat is Good for Your Health and the Planet.

6. **Humane Society International (2011). An HSI Report: The Impact of Animal Agriculture on Global Warming and Climate Change**
   Mitigating the animal agriculture sector's significant yet under-appreciated role in climate change is vital for the health and sustainability of the planet, the environment, and its human and nonhuman inhabitants. Reducing GHG emissions, especially from animal agriculture, is both urgent and critical. —[B]y far the single largest anthropogenic user of land‖ and responsible for 18% of human-induced GHG emissions,289 the farm animal production sector must be held accountable for its role in the climate crisis. More innovative approaches in animal agricultural practices and management must be actualized by raising awareness and providing price incentives for farmers and consumers to embrace more sustainable food systems. Individually, incorporating environmentally sound and animal welfare-friendly practices into daily life, including adopting consumptive habits less reliant on meat, eggs, and dairy products, can significantly slow the effects of climate change.

7. **Chatham House (2014). Climate Change's Forgotten Sector Global Public Opinion on Meat and Dairy Consumption. Report**
   Even with ambitious action to reduce the emissions intensity of livestock production, it is unlikely that global temperature rises can be kept below two degrees Celsius in the absence of a radical shift in meat and dairy consumption. Despite the clear case for action to tackle demand for meat and dairy products, there is a remarkable lack of policies, initiatives or campaigns to do so. The received wisdom among governments and campaign groups appears to be that trying to reduce consumption of animal products is at best too complex a challenge, and at worst risks backlash. However, this view remains untested and ignores the fact that government interventions and public campaigns in pursuit of societal benefits have successfully shifted consumer behaviour in the past, perhaps most prominently in the case of

smoking. The lack of attention afforded to the issue by governments and environmental groups contributes to a significant lack of understanding about the links between livestock and climate change among publics – an awareness gap. This is a problem in itself, as the multinational survey undertaken for this study indicates that low awareness translates to a lack of willingness to change behaviour in order to reduce emissions. Finally, in addition to an awareness gap, this paper has also highlighted a research gap. Given the importance of shifting consumption of meat and dairy products to the objective of avoiding dangerous climate change, there is remarkably little research on how best to do so.

8. **Chatham House (2015). Changing Diets Pathways to Lower Meat Consumption. Report (also an Executive summary and recommendations; Supplementary materials; and Assessing Public Understanding and Behaviour).**
   Governments are the only actors with the necessary resources and capacities to redirect diets at scale towards more sustainable, plant-based sources of protein. There is a considerable awareness gap regarding the links between livestock, diet and climate change. While awareness-raising alone will not be sufficient to effect dietary change, it will be crucial to ensuring the efficacy of the range of government policy interventions required. Unless disseminated and supported by trusted sources, new information that encourages shifts in meat-eating habits is likely to be met with resistance. Identifying trusted information-providers and adopting cooperative approaches among them will be critical to raising awareness and engaging the public in this issue. The report includes a set of recommendations to convince people to change habits.

9. **Worldwatch Institute (2014). Peak Meat Production Strains Land and Water Resources**
   Global meat production rose to an estimated 308.5 million tons in 2013, an increase of 1.4 percent over 2012. Alternative practices could reduce these environmental and health impacts, such as switching feed from grains to grass and other plants, using natural instead of synthetic fertilizers, and ending factory- style livestock operations. But dietary choices also make a big difference. Eating less meat typically means leading a less resource-intensive life. What matters, however, is not only how much meat people eat but also the kind of meat they consume.

10. **Center for Biological Diversity (2015). Costs and consequences. The real price of Livestock grazing on America's public lands**
    The US lower 48 states represents 1.9 billion acres. Of that 1.9 billion acres: 778 million acres of private land are used for livestock grazing (forest grazing, pasture grazing, and crop grazing), 345 million acres for feed crops, 230 million acres of public land are used for grazing livestock.

11. **WRI (2016), Shifting diets for a sustainable food future. World Resources Institute. Working paper. Writers: Ranganathan, J., Vennard, D., Waite, R., Dumas, P., Lipinski, B., Searchinger, T., & Globagri-WRR model authors.**
    In this paper, the last in the series, we assess the role of one consumption-based solution: shifting the diets of populations who consume high amounts of calories, protein, and animal-based foods. Specifically, we consider three interconnected diet shifts:1. Reduce overconsumption of calories. 2. Reduce overconsumption of protein by reducing consumption of animal-based foods. 3. Reduce consumption of beef specifically.

12. **Greenpeace (2019). *Enganchados a la carne. Cómo la adicción de Europa a la soja alimenta el cambio climático*. https://es.greenpeace.org/es/wp-content/uploads/sites/3/2019/06/Enganchados-a-la-carne.pdf**
    La industria de la soja está viviendo un boom. La producción mundial de soja es ahora más del doble que en 1997 gracias a la introducción de semillas genéticamente modificadas (GM) tolerantes a los herbicidas en la década de 1990, e impulsado por la creciente demanda de piensos para abastecer la fiebre de grandes granjas industriales que producen gran parte de la carne y los productos lácteos del mundo. Esta rápida expansión se está produciendo a costa de algunos de los entornos con mayor biodiversidad del planeta, entre otros la Amazonia y los bosques del Cerrado y el Gran Chaco en América del Sur, y está contribuyendo a la creciente crisis climática y de salud pública.

3. ARTICLES PUBLICATS A REVISTES CIENTÍFIQUES

1. **Beckett, J.L. & Oltjen, J.W. (1993). Estimation of the water requirement for beef production in the United States. *Journal of Animal Science*, 71(4):818-826.**
   Beef cattle directly consumed 760 billion L of water per year. Irrigation of crop feedstuffs for beef cattle required 12,991 billion L of water. Irrigated pasture for beef cattle production required an additional 11,243 billion L of water. Carcass processing required 79 billion L of water. The model estimates 3,682 L of developed water per kilogram of boneless meat for beef cattle production in the United States.

2. **Pimentel, D., Berger, B., Filiberto, D., Newton, M., Wolfe, B., Karabinakis, E., Clark, S., Poon, E., Abbett, E., Nandagopa, S. (2004): Water Resources: Agricultural and Environmental Issues. *Bioscience*, 54(10): 909-918.**
   Agriculture consumes about 70% of fresh water worldwide; for example, approximately 1000 liters (L) of water are required to produce 1 kilogram (kg) of cereal grain, and 43,000 L to produce 1 kg of beef.

3. **Eshel, G. & Martin, P.A. (2006). Diet, Energy, and Global Warming. *Earth Interactions* volume 10, paper 9.**
   You can reduce your carbon footprint more effectively by going vegan than by switching from a conventional car to a hybrid.

4. **McMichael, A. J., Powles, J. W., Butler, C. D., & Uauy, R. (2007). Food, livestock production, energy, climate change, and health. *The Lancet*, 370, 1253–1263.**
   To prevent increased greenhouse-gas emissions from this production sector, both the average worldwide consumption level of animal products and the intensity of emissions from livestock production must be reduced. Greenhouse-gas emissions from the agriculture sector account for about 22% of global total emissions; this contribution is similar to that of industry and greater than that of transport. Livestock production (including transport of livestock and feed) accounts for nearly 80% of the sector's emissions. A universal policy of demand reduction for all animal products in all countries, irrespective of current levels, would be politically infeasible, not least because of its obvious inequity. Not surprisingly, then, many key policy documents seem to have sidestepped this issue. Removing state subsidies for animal feed (corn and soy) would, via increases in retail prices, help to reduce meat consumption and redirect grain harvests to local low-income country diets. Meanwhile, total consumption of animal foods would, of course, be reduced by further slowing of world population growth, which could be achieved, without coercion, by education, leadership, and wider availability of contraceptive knowledge and methods.

5. **Galloway, J.N., et al. (2007) International trade in meat: The tip of the pork chop, *Ambio*, 36(8): 622-629.**
   Global land, water, and nitrogen use in support of industrialized livestock production and trade (pork and poultry). Authors calculate the amount of ''virtual'' nitrogen, water, and land used in production but not embedded in the product. Meat- importing countries, such as Japan, benefit from ''virtual'' trade in land, water, and nitrogen, and key meat- exporting countries, such as Brazil, provide these resources without accounting for their true environmental cost. Results show that Japan's pig and chicken meat imports embody the virtual equivalent of 50% of Japan's total arable land. 20% of Brazil's area is used to grow soybean exports.

6. **Fiala, N. (2008). Meeting the Demand: An Estimation of Potential Future Greenhouse Gas Emissions from Meat Production. *Ecological Economics* 67, 412-419.**
   Current production processes for meat products have been shown to have a significant impact on the environment, accounting for between 15% and 24% of current greenhouse gas emissions. Under an expanded CAFO system, meat production in the future will still be a large producer of greenhouse gases, accounting for up to 6.3% of current greenhouse gas emissions in 2030.

7. **Shindell, D.R., Faluvegi, G., Koch, D.M., Schmidt, G.A., Unger, N., Bauer, S.E. (2009). Improved Attribution of Climate Forcing to Emissions. *Science*, 326(5953): 716-718.**

Methane is 25-100 times more destructive than CO2 and has a global warming potential 86 times that of CO2 on a 20 year time frame.

13. **Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science and Policy* 12, 491–504.**
This paper reviews the life cycle analysis (LCA) approach to quantifying these emissions and argues that, given the dynamic complexity of our food system, it offers a limited understanding of livestock's GHG impacts. It is argued that LCA's conclusions need rather to be considered within a broader conceptual framework that incorporates three key additional perspectives. The first is an understanding of the indirect second order effects of livestock production on land use change and associated CO2 emissions. The second compares the opportunity cost of using land and resources to rear animals with their use for other food or non-food purposes. The third perspective is need—the paper considers how far people need livestock products at all.

8. **Goodland, R., & Anhang, J. (2009). Livestock and climate change. What if the key actors are ... cows, pigs, and chickens? *World Watch Magazine*, 22(6), 10–19. (The authors are former World Bank researchers).**
Livestock and their byproducts account for at least 32,000 million tons of carbon dioxide (CO2) per year, or 51% of all worldwide greenhouse gas emissions.

9. **Goodland, R., & Anhang, J. (2009). Commentary to Livestock and greenhouse gas emissions: The importance of getting the numbers right, by Herrero et al. [Anim. Feed Sci. Technol. 166–167, 779–782] *Animal Feed Science and Technology*, 172(3-4): 252–256.**
However, the commentary by Herrero et al. (2011) actually consisted mainly of a review of an article that we co-authored in World Watch (Goodland and Anhang, 2009). We believe that their commentary misstates some important facts, and in some areas risks misleading readers. For each such case, we will summarize the relevant statement by Herrero et al. (2011) and provide our response

10. **Carlsson-Kanyama, A. & González, A.D. (2009). Potential contributions of food consumption patterns to climate change. *The American Journal of Clinical Nutrition,* 89(5): 1704S-1709S.**
We suggest that changes in the diet toward more plant-based foods, toward meat from animals with little enteric fermentation, and toward foods processed in an energy-efficient manner offer an interesting and little explored area for mitigating climate change.

11. **Gill, M., Smith, P., Wilkinson, J.M. (2010). Mitigating climate change: the role of domestic livestock. *Animal* 4, 323–333.**
The policy community thus have difficult decisions to make in balancing the negative contribution of livestock to the environment against the positive benefit in terms of food security. The animal science community have a responsibility to provide an evidence base which is objective and holistic with respect to these two competing challenges.

12. **Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science* 327, 812–818.**
A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security, different components of which are explored here.

13. **Hoekstra, A.Y. (2010) The water footprint of animal products, In: D'Silva, J. and Webster, J. (eds.) *The meat crisis: Developing more sustainable production and consumption*, Earthscan, London, pp. 22-33.**
One single component in the total water footprint of humanity stands out: the water footprint related to the consumption of animal products. About 85 per cent of humanity's water footprint is related to the consumption of agricultural products; 10 per cent relates to industrial products and only 5 per cent to domestic water consumption (Hoekstra and Chapagain 2007, 2009). Within the category of agricultural products, animal products generally have a much larger water footprint per kilogram or calorific value than crop products. This means that if people consider reducing their water footprint, they are advised to look critically at their diet rather than at their water use in the kitchen, bathroom and garden.

14. **Mekonnen, M.M. and Hoekstra, A.Y. (2010) A Global Assessment of the Water Footprint of Farm Animal Product. *Ecosystems*, 15:401-415.**
The average water footprint per calorie for beef is 20 times larger than for cereals and starchy roots. The water footprint per gram of protein for milk, eggs and chicken meat is 1.5 times larger than for pulses. The unfavorable feed conversion efficiency for animal products is largely responsible for the relatively large water footprint of animal products. The study shows that from a freshwater perspective, animal products from grazing systems have a smaller blue and grey water footprint than products from industrial systems, and that it is more water-efficient to obtain calories, protein and fat through crop products than animal products.

15. **Hoekstra, A.Y. (2011) Understanding the water footprint of factory farming, *Farm Animal Voice*, 180: 14-15.**
The latest 2009 World Water Assessment Programme report by the United Nations is nearly 350 pages long but mentions the word 'meat¡ just 15 times. The analysis does not go deeper than stating that global meat demand will increase and thus water demand as well. The same bias can be seen in scientific literature, which generally addresses the issue of water-use efficiency within agriculture (more crop per drop), but hardly ever the issue of water-use efficiency in the food system as a whole (more calories per drop).

16. **O'Mara, F.P. (2011). The significance of livestock as a contributor to global greenhouse gas emissions today and in the near future. *Animal Feed Science and Technology*, 166-167, 7-15.**
Animal agriculture is responsible for 8–10.8% of global greenhouse gas (GHG) emissions as assessed by IPCC accounting and, on the basis of lifecycle analysis, the contribution of livestock is up to 18% of global emissions. Livestock related emissions will increase as world population and food demand increases; enteric CH4 emissions are projected to grow by over 30% from 2000 to 2020. There are mitigations available now, but it is imperative to develop new mitigations and ways to implement existing technologies more cost effectively.

17. **Herrero, M., Gerber, P., Vellinga, T. , Garnett, T. , Leip, A., Opio, C., Westhoek, H.J., Thornton, P.K., Olesen, J., Hutchings, N., Montgomery, H., Soussana, J.-F., Steinfeld, H., McAllister, T.A. (2011). Livestock and greenhouse gas emissions: The importance of getting the numbers right, *Animal Feed Science and Technology*, Volumes 166–167, 23 June 2011, Pages 779-782.**
Estimates of global greenhouse gases (GHG) emissions attributable to livestock range from 8 to 51%. This variability creates confusion among policy makers and the public as it suggests that there is a lack of consensus among scientists with regard to the contribution of livestock to global GHG emissions. In reality, estimates of international scientific organizations such as the International Governmental Panel on Climate Change (IPCC) and the Food and Agriculture Organization (FAO) are in close agreement, with variation mainly arising on how GHG emissions are allocated to land use and land use change. Other estimates involve major deviations from international protocols. Global estimates of livestock GHG emissions are most reliable when they are generated by internationally recognized scientific panels with expertise across a range of disciplines, and with no preconceived bias to particular outcomes.

18. **Janzen, H.H. (2011). What place for livestock on a re-greening earth? *Animal Feed Science and Technology*, 166-167, 783-796.**
Livestock have been implicated in many injurious processes: land use change, excess water use, nutrient excretion, fossil energy use, competition for food and emission of greenhouse gases. At the same time, they offer numerous benefits: producing food from human inedible sources, preserving ecosystem services, promoting perennials on croplands, recycling plant nutrients and providing social benefits. Thus livestock can be both stressors and benefactors to land and the aim of researchers should be to shift the net effect from stress to beneficence. Livestock offer many benefits to human society and often their place in ecosystems can be ecologically justified. But that does not mean that all ways of raising them are beneficial, nor that they necessarily fit everywhere. In coming decades, researchers, in concert with practitioners, consumers and policymakers, will need to show creativity, foresight and courage to envision new ways of melding animals into our ecosystems, not only to minimize harm, but to advance their re-greening.

19. **Lesschen, J.P., van der Berg, M., Westhoek, H.J., Witzke, H.P. and Oenema, O. (2011). Greenhouse gas emission profiles of European livestock sectors. *Animal Feed Science and Technology*, 166-167, 16-28**
There are increasing concerns about the ecological footprint of global animal production. Expanding livestock sectors worldwide contribute to expansion of agricultural land and associated deforestation, emissions of greenhouse gases (GHG), eutrophication of surface waters and nutrient imbalances. Farm based studies indicate that there are large differences among farms in animal productivity and environmental performance. Here, we report on regional variations in dairy, beef, pork, poultry and egg production, and related GHG emissions in the 27 Member States of the European Union (EU-27), based on 2003–2005 data.

20. **Hoekstra, A.Y. (2012) The hidden water resource use behind meat and dairy, *Animal Frontiers*, 2(2): 3-8.**
The consumption of animal products contributes to more than one-quarter of the water footprint of humanity. The water needed to produce feed is the major factor behind the water footprint of animal products. In industrialized countries, moving toward a vegetarian diet can reduce the food-related water footprint of people by 36%.

21. **Vermeulen, S.J., Campbell, B.M., & Ingram, J.S.I (2012). Climate Change and Food Systems. Annu. *Annual Review of Environmental Resources,* 37:195–222.**
Food systems contribute 19%–29% of global anthropogenic green- house gas (GHG) emissions, releasing 9,800–16,900 megatonnes of carbon dioxide equivalent (MtCO2e) in 2008. Agricultural production, including indirect emissions associated with land-cover change, con- tributes 80%–86% of total food system emissions, with significant re- gional variation. The impacts of global climate change on food systems are expected to be widespread, complex, geographically and tempo- rally variable, and profoundly influenced by socioeconomic conditions.

22. **CE Delft (2012). Behavioural Climate Change Mitigation Options and Their Appropriate Inclusion in Quantitative Longer Term Policy Scenarios. Main Report Delft, CE Delft, April 2012**
http://www.cedelft.eu/publicatie/behavioural_climate_change_mitigation_options_and_their_appropriate_inclusion_in_quantitative_longer_term_policy_scenarios/1290
This study has focused on emission reduction potentials not covered by the EU Emissions Trading System and identified 36 options for behavioural change in the mobility, housing and food domains that will, when realised, result in a decrease of GHG emissions. In the short term, a shift to a vegetarian diet is considered the behavioural change with highest mitigation potential.

23. **Gerbens-Leenes, P.W., Mekonnen, M.M. and Hoekstra, A.Y. (2013). The water footprint of poultry, pork and beef: A comparative study in different countries and production systems. *Water Resources and* Industry, 1–2:25–36.**
Agriculture accounts for 92% of the freshwater footprint of humanity; almost one third relates to animal products. In a recent global study, Mekonnen and Hoekstra (2012) [31] show that animal products have a large water footprint (WF) relative to crop products. We use the outcomes of that study to show general trends in the WFs of poultry, pork and beef.

24. **Miller, S.M., Wofsy, S.C., Michalak, A.M., Kort, E.A., Andrews, A.E., Biraud, S.C., Dlugokenckyd, E.J., Eluszkiewicz, J, Fischer, M.L., Janssens-Maenhout, G., Miller, B.R., Miller, J.B., Montzka, S.A., Nehrkorn, T. & Sweeney, C. (2013). Anthropogenic emissions of methane in the United States. *PNAS*, 110(50): 20018–20022.**
Methane emissions associated with both the animal husbandry and fossil fuel industries have larger greenhouse gas impacts than indicated by existing inventories. Cows produce 150 billion gallons of methane per day.

25. **Herrero, M., Havlik, P., Valin, H., Notenbaert, A., Rufino, MC., Thornton, P.K., Blümmel, M., Weiss, F., Grace, D., & Obersteiner, M. (2013). Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. *PNAS*, 110(52):20888–20893.**

We present a unique, biologically consistent, spatially disaggregated global livestock dataset containing information on biomass use, production, feed efficiency, excretion, and greenhouse gas emissions for 28 regions, 8 livestock production systems, 4 animal species (cattle, small ruminants, pigs, and poultry), and 3 livestock products (milk, meat, and eggs). Data provide critical information for developing targeted, sustainable solutions for the livestock sector and its widely ranging contribution to the global food system.

26. **Scarborough, P.; Appleby, P.N; Mizdrak, A.; Briggs, A.D.M; Travis, R.C.; Bradbury, K.E; Key, T.J. (2014): Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. *Climatic change* 125: 179-192.**
In conclusion, dietary GHG emissions in self-selected meat-eaters are approximately twice as high as those in vegans.

27. **Bajzelj, B.; Richards, K.S.; Allwood, J.M.; Smith, P.; Dennis, J.S.; Curmi, E.; Gilligan, C.A. (2014). Importance of food-demand management for climate mitigation. *Nature Climate Change* 4, 924–929.**
We quantify the potential for demand-side mitigation options, and show that improved diets and decreases in food waste are essential to deliver emissions reductions, and to provide global food security in 2050.

28. **Bajzelj, B. & Richards, K.S. (2014). The Positive Feedback Loop between the Impacts of Climate Change and Agricultural Expansion and Relocation. *Land,* 3: 898-916.**
In this paper, we consider the "missing link" of how climatic impacts alter agricultural contributions to GHG emissions, an important building block in understanding the whole feedback loop between climate change and agriculture. The increase in food demand from the growth in population and affluence is a critical driver for increased impacts. Therefore, mitigation efforts should also be focused on food demand as the first priority.

29. **Hedenus, F.; Wirsenius, S.; Johansson, D.J.A (2014). The importance of reduced meat and dairy consumption for meeting stringent climate change targets. *Climatic Change*, Volume 124, Issue 1-2, pp 79-91.**
We conclude that reduced ruminant meat and dairy consumption will be indispensable for reaching the 2 °C target with a high probability, unless unprecedented advances in technology take place.

30. **Eshel, G.; Shepon, A.; Makovc, T.; Milob, R. (2014). Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *PNAS*, vol. 111 no. 33, 11996–12001.**
The study thus elucidates the multiple environmental benefits of potential, easy-to- implement dietary changes, and highlights the uniquely high resource demands of beef.

31. **Westhoek, Henk et al (2014). Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. Global Environmental Change, 26: 196-205.**
Western diets are characterised by a high intake of meat, dairy products and eggs, causing an intake of saturated fat and red meat in quantities that exceed dietary recommendations. The associated livestock production requires large areas of land and lead to high nitrogen and greenhouse gas emission levels. Although several studies have examined the potential impact of dietary changes on greenhouse gas emissions and land use, those on health, the agricultural system and other environmental aspects (such as nitrogen emissions) have only been studied to a limited extent. By using biophysical models and methods, we examined the large-scale consequences in the European Union of replacing 25–50% of animal-derived foods with plant-based foods on a dietary energy basis, assuming corresponding changes in production. We tested the effects of these alternative diets and found that halving the consumption of meat, dairy products and eggs in the European Union would achieve a 40% reduction in nitrogen emissions, 25–40% reduction in greenhouse gas emissions and 23% per capita less use of cropland for food production. In addition, the dietary changes would also lower health risks. The European Union would become a net exporter of cereals, while the use of soymeal would be reduced by 75%. The nitrogen use efficiency (NUE) of the food system would increase from the current 18% to between 41% and 47%, depending on choices made regarding land use. As agriculture is the major source of nitrogen pollution, this is expected to

result in a significant improvement in both air and water quality in the EU. The resulting 40% reduction in the intake of saturated fat would lead to a reduction in cardiovascular mortality. These diet-led changes in food production patterns would have a large economic impact on livestock farmers and associated supply-chain actors, such as the feed industry and meat-processing sector.

32. **Hoekstra, A.Y. (2014) Water for animal products: a blind spot in water policy, *Environmental Research Letters*, 9(9): 091003.**
We know from land, energy and climate studies that the livestock sector plays a substantial role in deforestation, biodiversity loss and climate change. More recently it has become clear that livestock also significantly contributes to humanity's water footprint, water pollution and water scarcity. Jalava et al (Environ. Res. Lett. 9 074016) show that considerable water savings can be achieved by reducing the fraction of animal products in our diet. The findings are in line with a few earlier studies on water use in relation to diets. As yet, this insight has not been taken forward in national water policies, which focus on 'sustainable production' rather than 'sustainable consumption'. Most studies and practical efforts focus on increasing water-use efficiency in crop production (more crop per drop) and feed conversion efficiency in the livestock sector (more meat with less feed). Water- use efficiency in the food system as a whole (more nutritional value per drop) remains a blind spot.

33. **Tilman, D. & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature*, 515(7528): 518-522.**
Emissions for agriculture projected to increase 80% by 2050.

34. **Machovina, B., Feeley, K.J., Ripple, W.J. (2015). Biodiversity conservation: The key is reducing meat consumption. *Science of The Total Environment,* 536: 419–431.**
The consumption of animal-sourced food products by humans is one of the most powerful negative forces affecting the conservation of terrestrial ecosystems and biological diversity. Livestock production is the single largest driver of habitat loss, and both livestock and feedstock production are increasing in developing tropical countries where the majority of biological diversity resides. Livestock production is also a leading cause of climate change, soil loss, water and nutrient pollution, and decreases of apex predators and wild herbivores, compounding pressures on ecosystems and biodiversity. It is possible to greatly reduce the impacts of animal product consumption by humans on natural ecosystems and biodiversity while meeting nutritional needs of people, including the projected 2–3 billion people to be added to human population. We suggest that impacts can be remediated through several solutions: (1) reducing demand for animal-based food products and increasing proportions of plant-based foods in diets, the latter ideally to a global average of 90% of food consumed; (2) replacing ecologically-inefficient ruminants (e.g. cattle, goats, sheep) and bushmeat with monogastrics (e.g. poultry, pigs), integrated aquaculture, and other more-efficient protein sources; and (3) reintegrating livestock production away from single-product, intensive, fossil-fuel based systems into diverse, coupled systems designed more closely around the structure and functions of ecosystems that conserve energy and nutrients. Such efforts would also impart positive impacts on human health through reduction of diseases of nutritional extravagance.

35. **Persson, U.M.; Johansson, D.J.A.; Cederberg, C.; Hedenus, F.; Bryngelsson, D. (2015). Climate metrics and the carbon footprint of livestock products: where's the beef? *Environmental Research Letters,* 10**
Revealing that the metrics diminishing the impact of livestock are not actually what they seem to be.

36. **Erb, K-H., Lauk, C., Kastner, T., Mayer, A., Theurl, M.C., & Haberl, H. (2015). Exploring the biophysical option space for feeding the world without deforestation. *Nature Communications* | DOI: 10.1038/ncomms11382.**
We assess the biophysical option space for feeding the world in 2050 in a hypothetical zero-deforestation world. We systematically combine realistic assumptions on future yields, agricultural areas, livestock feed and human diets. For each scenario, we determine whether the supply of crop products meets the demand and whether the grazing intensity stays within plausible limits.

37. **Springmann, M., Godfray, H.C.J., Rayner, M., & Scarborough, P. (2016). Analysis and valuation of the health and climate change cobenefits of dietary change. *PNAS* 113(15): 4146–4151.**
We find that the impacts of dietary changes toward less meat and more plant-based diets vary greatly among regions. The largest absolute environmental and health benefits result from diet shifts in developing countries whereas Western high-income and middle-income countries gain most in per capita terms. Transitioning toward more plant-based diets that are in line with standard dietary guidelines could reduce global mortality by 6–10% and food-related greenhouse gas emissions by 29–70% com- pared with a reference scenario in 2050.

38. **Burns F, Eaton MA, Barlow KE, Beckmann BC, Brereton T, Brooks DR, et al. (2016) Agricultural Management and Climatic Change Are the Major Drivers of Biodiversity Change in the UK. *PLoS ONE* 11(3): e0151595. doi:10.1371/journal.pone.0151595**
We review drivers of change across four hundred species sampled from a broad range of taxonomic groups in the UK. We found that species' population change (~1970–2012) has been most strongly impacted by intensive management of agricultural land and by climatic change.

39. **Rivera-Ferre, M. G., López-i-Gelats, F., Howden, M., Smith, P., Morton, J. F., & Herrero, M. (2016). Re-framing the climate change debate in the livestock sector: mitigation and adaptation options. Wiley Interdisciplinary Reviews: Climate Change, 7(6), 869-892.**
The debate around livestock is confusing due to the coexistence of multiple livestock farming systems with differing functions for humans, greenhouse gas (GHG) emission profiles and different characteristics and boundary issues in their measurement, which are often pooled together. Consequently, the diversity of livestock farming systems and their functions to human systems are poorly represented and the role of the livestock sector in the climate change debate has not been adequately addressed. In this article, building upon the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC 5AR) findings, recent literature on livestock and climate change is reviewed so as better to include this diversity in the adaptation and mitigation debate around livestock systems.

40. **Springmann, Marco (2018). Options for keeping the food system within environmental limits. *Nature*, 562: 519-525.**
The food system is a major driver of climate change, changes in land use, depletion of freshwater resources, and pollution of aquatic and terrestrial ecosystems through excessive nitrogen and phosphorus inputs. Here we show that between 2010 and 2050, as a result of expected changes in population and income levels, the environmental effects of the food system could increase by 50–90% in the absence of technological changes and dedicated mitigation measures, reaching levels that are beyond the planetary boundaries that define a safe operating space for humanity. We analyse several options for reducing the environmental effects of the food system, including dietary changes towards healthier, more plant-based diets, improvements in technologies and management, and reductions in food loss and waste. We find that no single measure is enough to keep these effects within all planetary boundaries simultaneously, and that a synergistic combination of measures will be needed to sufficiently mitigate the projected increase in environmental pressures.

41. **Poore, Joseph & Nemecek, Thomas (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360 (6392) 987-992.**
Food's environmental impacts are created by millions of diverse producers. To identify solutions that are effective under this heterogeneity, we consolidated data covering five environmental indicators; 38,700 farms; and 1600 processors, packaging types, and retailers. Impact can vary 50-fold among producers of the same product, creating substantial mitigation opportunities. However, mitigation is complicated by trade-offs, multiple ways for producers to achieve low impacts, and interactions throughout the supply chain. Producers have limits on how far they can reduce impacts. Most strikingly, impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change. Cumulatively, our findings support an approach where producers monitor their own impacts, flexibly meet environmental targets by choosing from multiple practices, and communicate their impacts to consumers.

42. **Heller, Martin C. & Keoleian, Gregory A. (2018). Beyond Meat's Beyond Burger Life Cycle Assessment: A detailed comparison between a plant- based and an animal-based protein source. Centre for Sustainable Systems, Report No. CSS18-10, University of Michigan.**
Based on a comparative assessment of the current Beyond Burger production system with the 2017 beef LCA by Thoma et al, the Beyond Burger generates 90% less greenhouse gas emissions, requires 46% less energy, has >99% less impact on water scarcity and 93% less impact on land use than a ¼ pound of U.S. beef.

43. **Lynch, John & Pierrehumbert, Raymond (2019). Climate Impacts of Cultured Meat and Beef Cattle. *Frontiers is Sustainable Food Systems*, https://www.frontiersin.org/articles/10.3389/fsufs.2019.00005/full.**
In this study, we present a more rigorous comparison of the potential climate impacts of cultured meat and cattle production than has previously been made. Cattle systems are associated with the production of all three GHGs above, including significant emissions of CH4, while cultured meat emissions are almost entirely CO2 from energy generation. Under continuous high global consumption, cultured meat results in less warming than cattle initially, but this gap narrows in the long term and in some cases cattle production causes far less warming, as CH4 emissions do not accumulate, unlike CO2. We conclude that cultured meat is not prima facie climatically superior to cattle; its relative impact instead depends on the availability of decarbonized energy generation and the specific production systems that are realized.

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