

Green revolution and its impact on the environment and women farmers

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While green revolution was an urgent necessity at the time of its introduction, in the Indian context, today the country is food secure, but is faced with the immense challenge of climate change that has put at great risk the fruits of that hard-fought battle. Climate change is putting at greater risk at least 55%, if not all, of the net sown area - classified as rain fed regions – that do not have access to secured to irrigation. Today's Agriculture – production cycle of inputs and agriculture itself – contributes to one third (2012) of all anthropogenic emission of greenhouse gases a sizable chunk of all greenhouse gas production. By comparison, the transportation sector contributes 23% of all anthropogenic emission of greenhouse gases.

The green revolution, has for women been a largely disempowering experience as it lead to greater dismissal of their contribution in agriculture, dismantling of local systems to which women had greater access, exclusion of women from gaining of new knowledge associated with green revolution practices and exclusion of state support due to the linking of all state support to ownership of land, more often than not, held by men.

While the consequences of these are varied and complex, this paper seeks to explore the implications of the exclusion of women – knowledge women held, practices women undertook - on the environment. This is sought to be done through the examination of these practices and how they were more sustainable

agricultural practices while also having the potential in contributing to the development of better more sustainable practices. These also keep with other Sustainable Development goals viz. goal 3, 5, 11 and 13 – good health and wellbeing, gender equality, sustainable cities and communities, climate action and life on land.

The paper will examine practices that existed as regards seeds and diversity, what crops were grown and cropping, and what has changed post green revolution. It will look at practices that were prevalent - more diverse crops, inter-cropping/ mixed cropping, and methods/ techniques used in that regard. In doing so, it also looks at changes the green revolution brought and the consequences of these changes on the environment, increased exclusion of women and consequences for nutritional security for the household.

Introduction

Abject hunger and malnutrition are what India found itself facing immediately post-independence. India in 1965-66 was facing an 18 million tons shortfall in food grains with respect to the government's estimate requirement of 95 million tons. While that year the short fall was met with massive aids, primary from the US (to the tune of around one fifth of that year's total harvest in the US). This was referred to often as "ship-to-mouth" existence. The years after that saw food aid continuing till India could produce enough or had the ability to buy what it needed because of what came to be known as the Green Revolution.

While the claims of food sufficiency are hailed as achievements the figures show a slightly different picture in that we are barely coping in

terms of meeting needs. In 1961, per capita food production stood at 170.61 Kgs (468.7 grams/day), while in 1971 it was at 170.64 Kgs (468.8 grams/day). As per provisional estimates for 2017, the per day per capita food grain production is estimated at 485.4 grams or 176.68 kg for the year. While the per capita production of food grains does not translate to per capita availability due to losses in storage and other wastages, there has been an increase in per capita availability from 422gm in 2000 to 468gm in 2013. While these values have brought the country closer than ever before to achieving (a narrowly defined) food security, even this stands threatened by climate change today.

Climate change, food security and agriculture

The hard-fought fruits of food security are under risk for a plethora of reasons. Regions in lower latitudes have been seeing and will

continue to see a loss in land available for agriculture – arid land due to climate change. India falls squarely in this region.¹ In addition to this, despite growing population there is relatively little change in per unit area food grain production. Making things more difficult, long term mono-cropping/ monoculture – the model pushed around the world and also by the green revolution in India - has also shown to cause decreasing yield.²

Many crops are at the end of their tolerable temperatures.³ With increasing temperature, there has been observed, in various parts of the world, a decreasing yield, further exacerbating our food security woes.⁴

The largescale use of insecticides and other chemicals to protect crops, among other reasons, has also led to the crashing of insect populations, having a two fold impact on agriculture directly viz. consequences for

¹ The third IPCC report as cited in *G.G.S.N. Rao*, Impacts of Climate Change in Rainfed Agriculture, (<http://www.crida.in/DRM2-Winter%20School/GGSNR.pdf>) (last viewed on 9th March 2019); See also *Xiao Zhang and Ximing Cai*, Climate change impacts on global agricultural land availability 2011, Environmental Research Letters, Volume 6, Number 1 (<https://iopscience.iop.org/article/10.1088/1748-9326/6/1/014014/pdf>)

² *R. C. Magarey*, Reduced productivity in long term monoculture: where are we placed?, Australasian Plant Pathology 1999 (<https://link.springer.com/article/10.1071/AP99002>) (last viewed on 9th March 2019); See also: *A.L. Garside et al*, Managing yield decline in sugarcane cropping systems, 2005, International Sugar Journal, (https://www.researchgate.net/publication/279907685_Managing_yield_decline_in_sugarcane_cropping_systems) (last viewed on 9th March 2019); *Qingyun Zhao*, Long-Term Coffee Monoculture Alters Soil Chemical Properties and Microbial Communities, Nature 2018, (<https://www.nature.com/articles/s41598-018->

[24537-2](https://doi.org/10.1016/S1573-5214(01)80026-9)) (last viewed on 9th March 2019); *F.Nevens*, Crop rotation versus monoculture; yield, N yield and ear fraction of silage maize at different levels of mineral N fertilization ([https://doi.org/10.1016/S1573-5214\(01\)80026-9](https://doi.org/10.1016/S1573-5214(01)80026-9)) (last viewed on 9th March 2019).

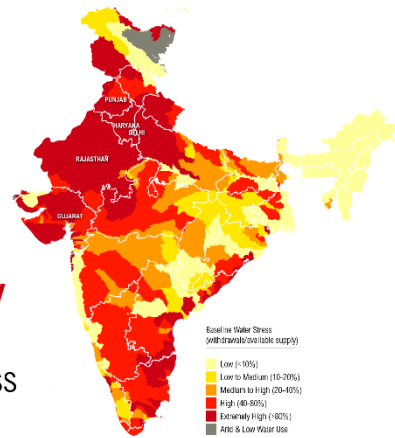
³ IPCC 2001 as cited in *G.G.S.N. Rao*, Impacts of Climate Change in Rainfed Agriculture, Central Research Institute for Dryland Agriculture (<http://www.crida.in/DRM2-Winter%20School/GGSNR.pdf>) (last viewed on 9th March 2019).

⁴ *Chuang Zhao et al*, Temperature increase reduces global yields of major crops in four independent estimates (2017), Proceedings of the National Academy of Sciences, (https://www.researchgate.net/publication/319137298_Temperature_increase_reduces_global_yields_of_major_crops_in_four_independent_estimates) (last viewed on 9th March 2019). See also: *Taufiq Yuliawan et al*, The effect of temperature rise to rice crop yield in Indonesia uses Shierary Rice model with geographical information system (GIS) feature

pollination – decreasing agricultural output qualitatively and quantitatively – and also increased threat of other pests to crops, whose populations were controlled by these insects.⁵ It also has dire consequences for the environment as insects form the food base for large number of live forms and with their mass dwindling, it threatens populations of a host of other life forms.

The intensification of agriculture, particularly water intensive crops, has left in a critically alarming state, ground water quality and levels in the country. The following 4 maps and graph is indicative of the same and trend of increasing reliance on ground water as opposed to canal-based irrigation in the country. What this has meant is, many, if not most places of indiscriminate ground water exploitation has seen a plummeting of the ground water levels and consequently, failure of bore wells, many of which were dug by borrowing – further intensifying the debt crisis farmers already face.

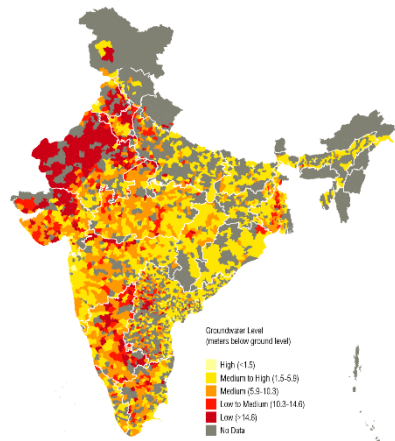
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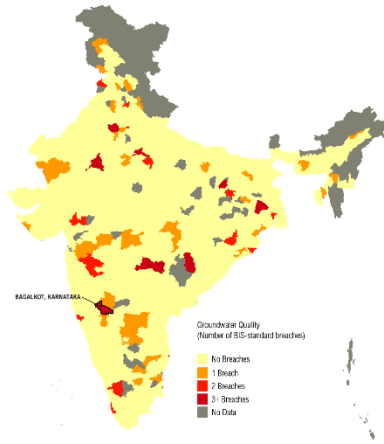
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⁵ Caspar A. Hallmann et al, More than 75 percent decline over 27 years in total flying insect biomass in protected areas, (<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0185809#sec011>) (last viewed on 9th March 2019); See also: The threat declining insect populations pose to agriculture and development,

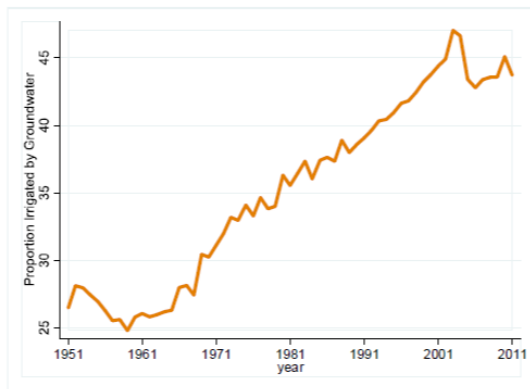
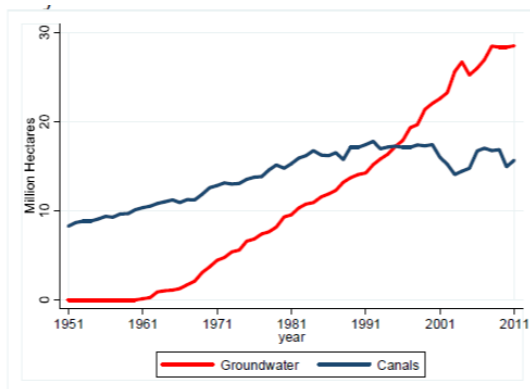
and what we can do about it (2019), International Food Policy Research Institute, (<http://www.ifpri.org/blog/threat-declining-insect-populations-pose-agriculture-and-development-and-what-we-can-do-about>) (last viewed on 9th March 2019).

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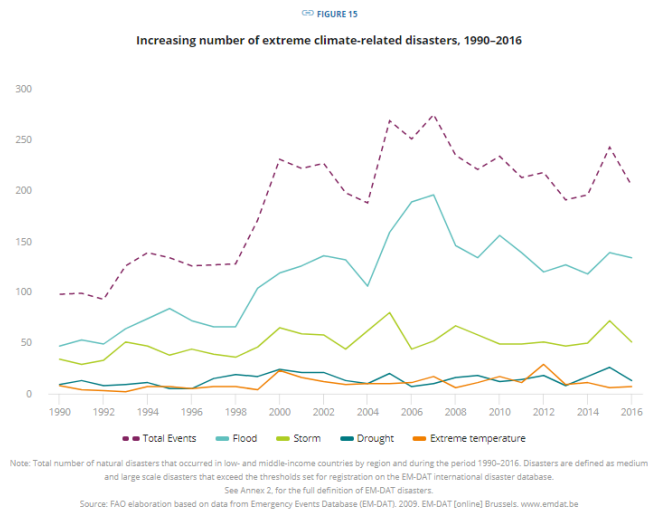


Graph shows increase in proportion of ground water usage to total net irrigated area between 1950 and 2011
Source: Agricultural Census, 1996-2011

⁶ FAO, Food Security & Nutrition around the World, (<http://www.fao.org/state-of-food-security-nutrition/en/>) (last viewed on 9th March 2019).

Source: Revitalising Rainfed Agriculture Network’s rainfed atlas

Increased frequency of extreme weather phenomenon has only piled on to the risks climate change has thrown at the sector and food security for the country.



Source: FAO, Food Security & Nutrition around the World⁶

Agriculture’s contribution to the emission of Green House Gases (GHGs) through production cycle of inputs and agriculture itself contributes to one third (2012) of all anthropogenic emission of greenhouse gases a sizable chunk of all greenhouse gas production.

With increased land under water intensive crop cultivation, ammonia use in the form of nitrogen fertilizers and standing water in flood irrigation, as is common for paddy, there has been increasing amounts of methane emissions significantly increasing heat trapping in the atmosphere.⁷

⁷ IPCC, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, 4.53, (<https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref5.pdf>);

Women and agriculture

Like all work undertaken, work in agriculture as well, is gendered. As is the case in most other sectors, women's work is either undervalued or not recognised at all. Here we explore how some practices that were undertaken by women – managed and or controlled – pre-green revolution and some of a more recent nature, are ecologically more sustainable. While each of these practices are limited in the geography in which they are practiced, they are indicative of possible solutions in terms of practices for a more sustainable agriculture.

There are references to women included in decision making and having control or greater control, what is meant is that it indicates more relative inclusion or greater control, or instances where greater control has been possible, like in instances of women headed households, single women run farms.

Some Practices

Many of the practices referred to in this section have been around for a long time, others are relatively recent. Many if not most of the practices described in this section have not been documented earlier and hence do not have references or citations. The practices highlighted are believed to be more sustainable based on evidence of methods or practices and their identified causes being absent in these processes. Some claims have more direct

evidence and others need to be further explored.

In addition to these practices being more environmentally sustainable or less damaging, by virtue of having included women, to a greater extent that is found commonly today, in decision making, management and control, had/have left women more empowered.

Agriculture or etymologically, culturing on the field, is possible because of domesticated varieties of crop plants. It is estimated that around 7000 species and countless varieties of plants have been used as food by humans but of these only 150 species are commercially significant and rice, wheat and maize account for 60 percent of global food supply.⁸

Seed selection, pre-processing and seed storage is in many, if not most places, where reliance of seed is not on the market, are activities almost exclusively undertaken by women.⁹ These processes were enriched by constant exchange between women farmers, communally, sharing information and knowledge on characteristics and the like. The diversity of varieties not only hedged against risks induced by the vagaries of nature but also contributed to a diversified food basket and consequently better nutrition of populations. They were also more suitable to the agroecological conditions of each region, making them more sustainable. Globalisation and green revolution with its penchant for uniformity and scale wiped out much of this diversity – increasing risks. With the

Joshua Schimel, Rice, microbes and methane, (<https://doi.org/10.1038/35000325>) (last viewed on 9th March 2019).

⁸ Changes in food habits and crop genetic diversity, Fourth session, 2007, (<http://www.fao.org/3/i2043e/i2043e02a.pdf>) (last viewed on 9th March 2019).

⁹ Priya Talwar, 75% of world's seeds are preserved by small farmers, mostly women, (2018), (<https://www.downtoearth.org.in/news/agriculture/75-of-world-s-seeds-are-preserved-by-small-farmers-mostly-women-60341>) (last viewed on 9th March 2019).

introduction of new hybrids or High Yielding Varieties (HYVs), entire knowledge systems needed to be replaced and new systems be made more familiar through information dissemination. With women consistently excluded from such extension services, were increasingly relegated to the role of mere agriculture labour with decreasing control or decision-making opportunities.

In Chhattisgarh and other parts of eastern India, as in many other parts of the world, the practice of fish rice farming is an old one.¹⁰ There is an increasingly large amount of literature attesting to the gendered division of labour in paddy fields around the world but also particularly in India. Through them, that women undertake most of the work in paddy fields is uncontested. It is no different in these fish rearing rice fields in eastern India. The practice in addition to risk reduction, augmented family income and bettered nutrition of the household, plays a role in controlling weed growth, decreased pest problems, conserving and increasing soil fertility – adding up to relatively more sustainable practice.¹¹ The practice has also been shown to have lesser GHG emissions particularly that of methane.¹²

¹⁰ FAO, Culture of fish in rice fields (<http://www.fao.org/3/a-a0823e.pdf>) (last viewed on 9th March 2019).

¹¹ S.A Noorhosseini *et al*, Ecological and Biological Effects of Fish Farming in Rice Fields, (https://www.researchgate.net/publication/259291397_Ecological_and_Biological_Effects_of_Fish_Farming_in_Rice_Fields) (last viewed on 9th March 2019).

¹² Wei-ling Yuan, Methane and Nitrous Oxide Emissions from Rice-Duck and Rice-Fish Complex Ecosystems and the Evaluation of Their Economic Significance (<https://www.sciencedirect.com/science/article/pii/S1671292708603351>) (last viewed on 9th March 2019).

Intercropping has been another practice that has been a part of traditional agricultural systems for a long time. Intercropping has been shown to decrease GHG emissions especially when cover crops, particularly when leguminous plants are used.¹³ They help reduce emissions of both Nitrous Oxides and carbon dioxide emissions.¹⁴

In many places today, like in Anantapuramu of Andhra Pradesh India, many women sow pulses and lentils between the main crop without informing men. It is a practice that evolved post the shift to groundnut as the major crop in the region. Anantapuramu is a district with highly irregular rainfall and receiving one of the lowest amounts of rain in the country.¹⁵ Due to this crop failure is unfortunately very common. This leaves no food for the household and also no income from the field.

Mixed cropping an old practice across the country, has also shown to bring multiple benefits apart from decreased GHG emissions, including bringing better balance to the input and output of soil nutrients, control weed growth and insect populations, control plant

¹³ Guillermo Guardia *et al*, Effect of cover crops on greenhouse gas emissions in an irrigated field under integrated soil fertility management (<https://core.ac.uk/download/pdf/148683611.pdf>) (last viewed on 9th March 2019).

¹⁴ Fabio Stagnari *et al*, Multiple benefits of legumes for agriculture sustainability: an overview, (<https://chembioagro.springeropen.com/articles/10.1186/s40538-016-0085-1>) (last viewed on 9th March 2019).

¹⁵ Department of Mines And Geology, District Survey Report - Anantapuramu District (2018), (<https://www.mines.ap.gov.in/miningportal/downloads/applications/anantapur.pdf>)

disease, resist climate extremes and also increase overall productivity.¹⁶

In Pandher Kawda, Maharashtra it was a common practice for women to grow small and short-term crops such as green leafy food stuffs, mostly for household-consumption, augmenting household nutrition. These crops were entirely managed by women, including its sale, whenever undertaken.

Harvesting of this produce was generally undertaken at the time of weeding, an activity almost exclusively undertaken by women. Such crops have also been shown to have decreased GHG emissions.¹⁷ The practice though is hardly found now, post the introduction of cash crops in the region and consequently, control and decision making as to what will be planted rests almost exclusively with men.

In Yavatmal Maharashtra, another practice called 'pata', which refers to both a piece of land and this particular type of land use, where a patch of land, out of the land worked by a

household, vegetables are grown.¹⁸ This patch is worked exclusively by women and is recognised as the exclusive domain of women as well.¹⁹ A recent revival of this practice has shown significant improvements in nutrition of households, money in the hands of women and served as drought risk mitigation strategy.²⁰

Earlier practices of using manure (slurry) and the process of making has been shown to be a cause of GHG emissions, particularly methane, but a more recent study has shown that when appropriate modification for ecological conditions are made their GHG emissions are lesser than chemical fertilisers.²¹ Manure application most often is undertaken by women²² and with the increased resort to inorganic fertilisers, women have lesser control over its use with increased consequences for their health. Furthermore, despite it being a less favourable option, access to fertilisers and limited access to knowledge on its use, also sets women behind on yield output when compared to men farmers.²³

¹⁶ Cropping Systems to Improve Carbon Sequestration for Mitigation of Climate Change, (2010), Journal of Environmental Protection, (https://www.researchgate.net/publication/228661843_Cropping_Systems_to_Improve_Carbon_Sequestration_for_Mitigation_of_Climate_Change) (last viewed on 9th March 2019).

¹⁷ *Mirjam E. van de Kamp et al*, Healthy diets with reduced environmental impact? – The greenhouse gas emissions of various diets adhering to the Dutch food based dietary guidelines, (2018), Food Research international, (<https://www.sciencedirect.com/science/article/pii/S0963996917302594>) (last viewed on 9th March 2019); See also: *Sylvia H. Vetter*, Greenhouse gas emissions from agricultural food production to supply Indian diets: Implications for climate change mitigation, (2019), Agriculture, Ecosystems & Environment, (<https://doi.org/10.1016/j.agee.2016.12.024>) (last viewed on 9th March 2019).

¹⁸ *Aparna Pallavi*, Women grow food basket: Maharashtra district revives an old farm practice and tackles drought, (2015), (<https://www.downtoearth.org.in/coverage/women-grow-food-basket-2683>) (last viewed on 9th March 2019).

¹⁹ *Ibid.*

²⁰ *Ibid.*

²¹ *Fengling Ren et al*, A synthetic analysis of greenhouse gas emissions from manure amended agricultural soils in China (<https://www.nature.com/articles/s41598-017-07793-6>) (last viewed on 9th March 2019).

²² *P C Tripathi*, Analysis of Participation of Women in Horticultural Activities (2015), Journal of Business Management & Social Sciences Research, (http://agritech.tnau.ac.in/women_in_agri/pdf/index/horti.pdf)

²³ *Cathy Rozel Farnworth et al*, Gender and inorganic nitrogen: what are the implications of moving towards a more balanced use of nitrogen fertilizer in

Intensive and extensive livestock rearing, women farmers and the environment

While livestock rearing has, legitimately, been indicted as one of the largest emitters of GHGs,²⁴ a growing understanding is that they are more a comment on intensive systems. Very little work has been done on extensive or grazing livestock systems in this regard but most of what exists is myopic in its assessment in terms of what the benefits from cattle rearing are, often limited to milk and meat in the current framework.²⁵ While large scale milk and meat production in intensive systems have limited other benefits, occasionally recognised as a source of manure,²⁶ extensive livestock rearing systems perform other functions as well including bettering soil health of common pasture lands, increased biodiversity, cultural integrity, food security for the household and community, energy needs for transportation and agriculture operations, and also serves as emergency funds, in times of need.²⁷ The use of animals for energy needs also offsets emissions from the lifecycles of mechanisation and fossil fuel burning for the operating of many of these machines. This in addition to limited expenses that rearing these animals causes pastoralists to

the tropics?

(<https://www.tandfonline.com/doi/full/10.1080/14735903.2017.1295343>)

²⁴ FAO, Tackling Climate Change Through Livestock: A global assessment of emissions and mitigation opportunities, (2013) (<http://www.fao.org/3/a-i3437e.pdf>); See also: FCRN, Grazed and confused? (https://www.fcrn.org.uk/sites/default/files/project-files/fcrn_gnc_report.pdf) (last viewed on 9th March 2019).

²⁵ Sagari R. Ramdas, Grazed and Not Confused: Why Not All Livestock Rearing Practices Are Ecologically Unsound (2017) (<https://thewire.in/agriculture/india-livestock-rearing-climate-change-oxford-university>) (last viewed on 9th March 2019).

²⁶ *Ibid.*

incur, as they are not capital intensive. There is an understanding among pastoralist communities and some work that credits livestock rearing in and around forests with controlling wild fires making it possible for forests to better sequester carbon, allowing them to truly be carbon sinks.²⁸ Their grazing in forests also help recycle nutrients allowing for better growth of these forests.

Most care work associated with Livestock rearing is, more often than not, undertaken by women,²⁹ except when seasonal migration is undertaken in search of pasture. As with other movements towards increased production and economic efficiency, there has been concerted efforts towards homogenisation and moving towards an input intensive system.³⁰ This came with the similar consequences for women as with the green revolution. With efforts to homogenise cattle and other livestock, women have also been left in the lurch as to how differently to take care of the new cross-bred or other alien animal breeds being thrust on them. While there is decreased utility in terms of the various purposes these animals can be put to use for, increased labour women have to put in in care work, and a very likely increased GHG

²⁷ *Ibid.*

²⁸ Francisco Moreira *et al*, Agriculture policy can reduce wildfires, (2018), (<http://science.sciencemag.org/content/359/6379/1001.1>) (last viewed on 9th March 2019).

²⁹ Durgga Rani V, Training needs of farm women in dairy farming, Veterinary World, 2009, (<http://www.veterinaryworld.org/Vol.2/June/Training%20needs%20of%20farm%20women%20in%20dairy%20farming.pdf>) (last viewed on 9th March 2019).

³⁰ World Bank Operations Evaluation Department, India: The Dairy Revolution, World Bank, ([http://lnweb90.worldbank.org/oed/oeddoelib.nsf/b71ec897615187985256885007b6ad0/1bdd436f3bb1c0d68525684800767e4e/\\$FILE/India_Dairy.pdf](http://lnweb90.worldbank.org/oed/oeddoelib.nsf/b71ec897615187985256885007b6ad0/1bdd436f3bb1c0d68525684800767e4e/$FILE/India_Dairy.pdf)) (last viewed on 9th March 2019).

emission, considering its limited uses and increased input requirement, do not seem to have been a consideration at all, either at the time of framing of such policies or thereafter. Moreover, despite care work still squarely placed on women's shoulders, like with farm labour, they were and continue to be excluded from the extension services that would better equip them to undertake care work.

Conclusion:

Food security is of paramount importance specially to developing countries like India. The green revolution helped the country edge closer to the calorie definition of food security, but even that narrowly defined food security is now threatened by climate change.

We have seen the impact of various specific activities and their consequent impact on the environment, be they on other life forms and the chain of consequences therefrom or the large emissions of Green House gases.

We then looked at specific practices, both traditional and more recent, undertaken by women farmers that were both, greener and more contributed to nutrition security of the household and the community.

As regards livestock, the differences in contexts and methods of assessment of utility we saw could be severely overestimating its unfavourable impact in terms of GHG emissions.

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