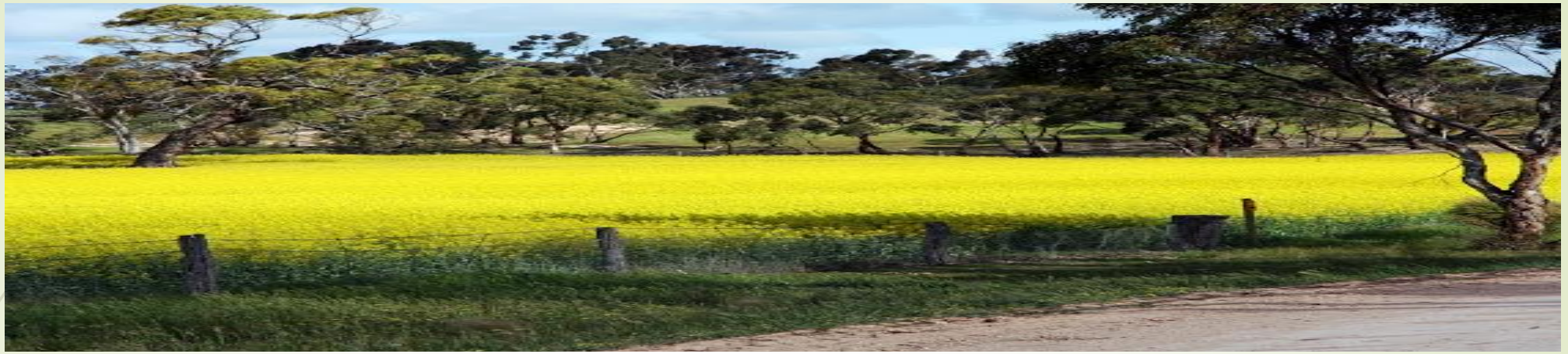
Global Impact of Biotech Crops: economic and environmental effects 1996-2018

Graham Brookes
PG Economics Ltd
UK

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Background

- 14th annual review of global GM crop impacts
- Authors of more than 30 papers on GM crop impacts in peer review journals
- Current review in 2 open access papers in journal GM Crops. www.tandfonline.com/toc/kgmc20/current
- Full report available at www.pgeconomics.co.uk

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Coverage

- Cumulative impact: 1996-2018
- Farm income and productivity impacts: focuses on farm income, yield, production
- Environmental impact analysis covering pesticide spray changes and associated environmental impact
- Environmental impact analysis: greenhouse gas emissions

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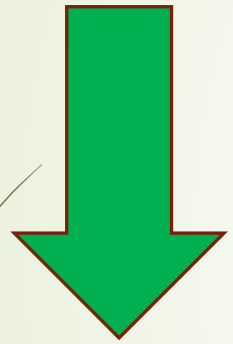
Methodology

- Review and use of considerable impact literature plus own analysis – a lot of this is in peer reviewed journals
- Uses current prices, exchange rates and yields (for each year) and update of key costs each year: gives dynamic element to analysis
- Review of pesticide usage (volumes used) or typical GM versus conventional treatments
- Use of Environmental Impact Quotient (EIQ) indicator
- Review of literature on carbon impacts – fuel changes and soil carbon

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Summary of key findings

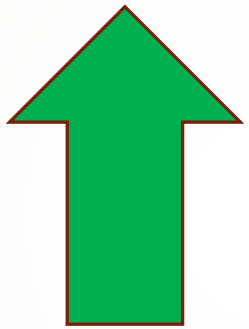
Pesticide change 1996-2018



776 million kg

reduction in pesticides (8.6%) & 19% cut in associated environmental impact

Global farm income 1996-2018



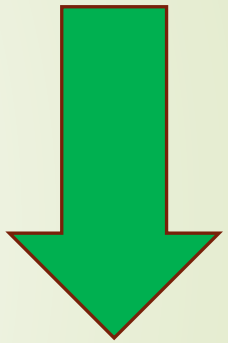
$225 billion increase

Global production 1996-2018



824 million tonnes more food/feed/fibre

Carbon emission 2018



cut of 23 billion kg CO2 release; equal to taking 15.3 million cars off the road

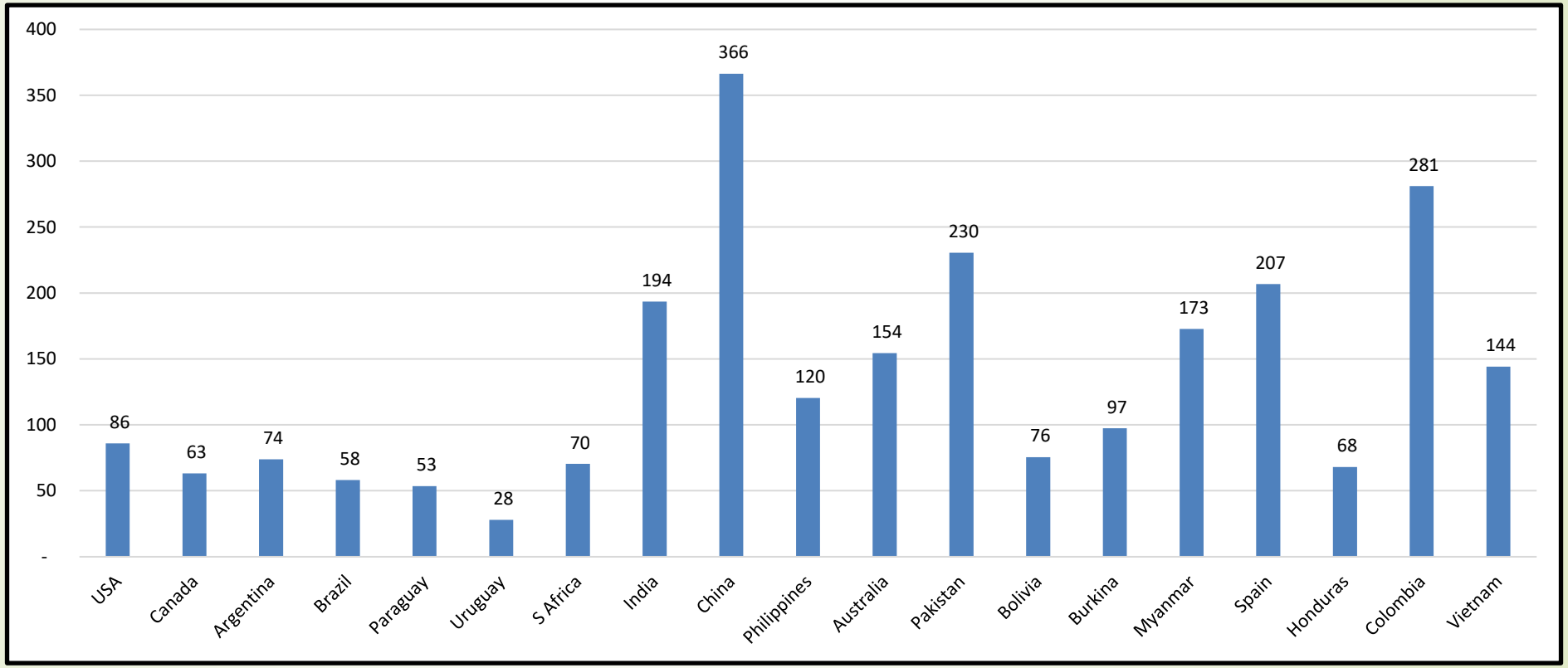
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Farm income gains: highlights

- Total farm income benefit 2018 $19 billion
- Equal to adding 5.8% to value of global production of corn, canola, cotton and soybeans
- Total farm income gain: 1996-2018: $225 billion
- Average gain/hectare (1996-2018): $97
- Income share (1996-2018): 48% developed and 52% developing countries

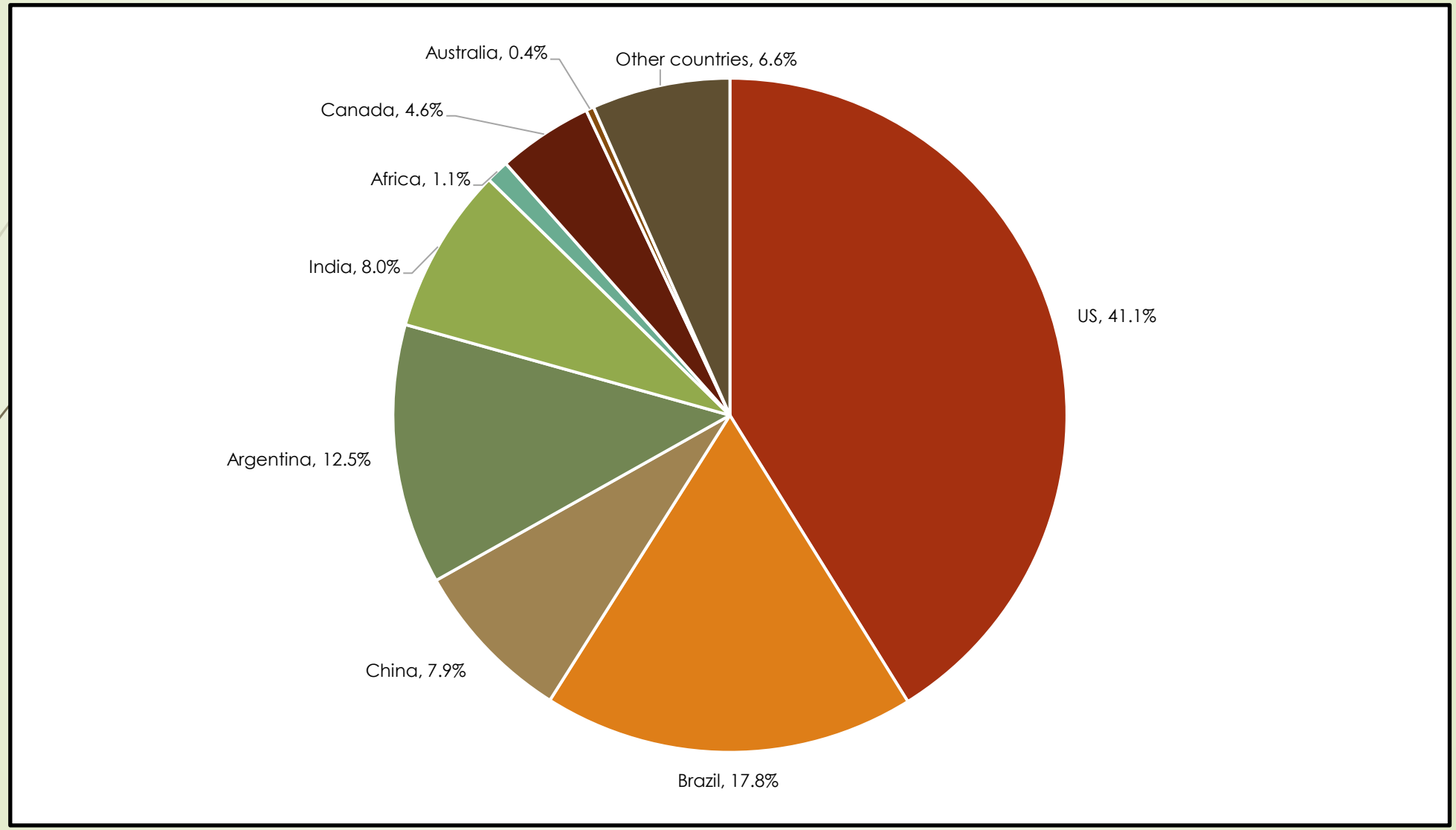
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Average farm income gain 1996-2018 by country ($/ha)



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Farm income gains 1996-2018 by country (US $)



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Other farm level benefits

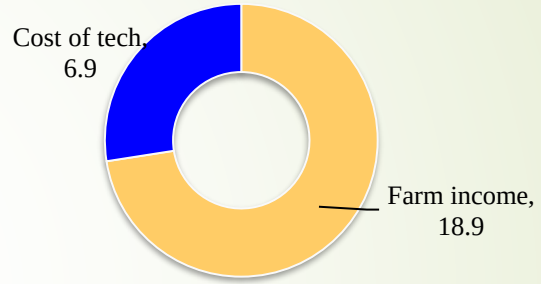
GM HT crops	*GM IR crops*
Increased management flexibility/convenience	Production risk management tool
Facilitation of no till practices	Machinery and energy cost savings
Cleaner crops = lower harvest cost and quality bonus	Yield gains for non GM crops (reduced general pest levels)
	Convenience benefit
	Improved crop quality
	Improved health and safety for farmers/workers

In US these benefits valued at $17 billion 1996-2018

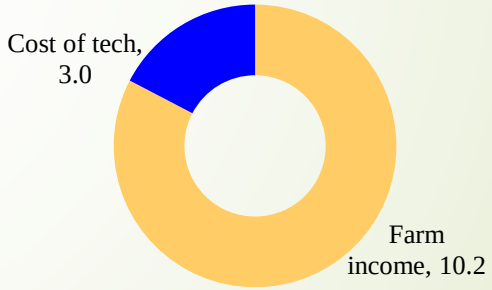
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Cost of accessing the technology ($billion) 2018

- Distribution of total trait benefit: all (tech cost 27%) – **every $1 invested in seed = $3.75 in extra income**



- Distribution of benefit: developing countries (tech cost 23%) **every $1 invested in seed = $4.42 in extra income**



Cost of tech goes to seed supply chain (sellers of seed to farmers, seed multipliers, plant breeders, distributors & tech providers)

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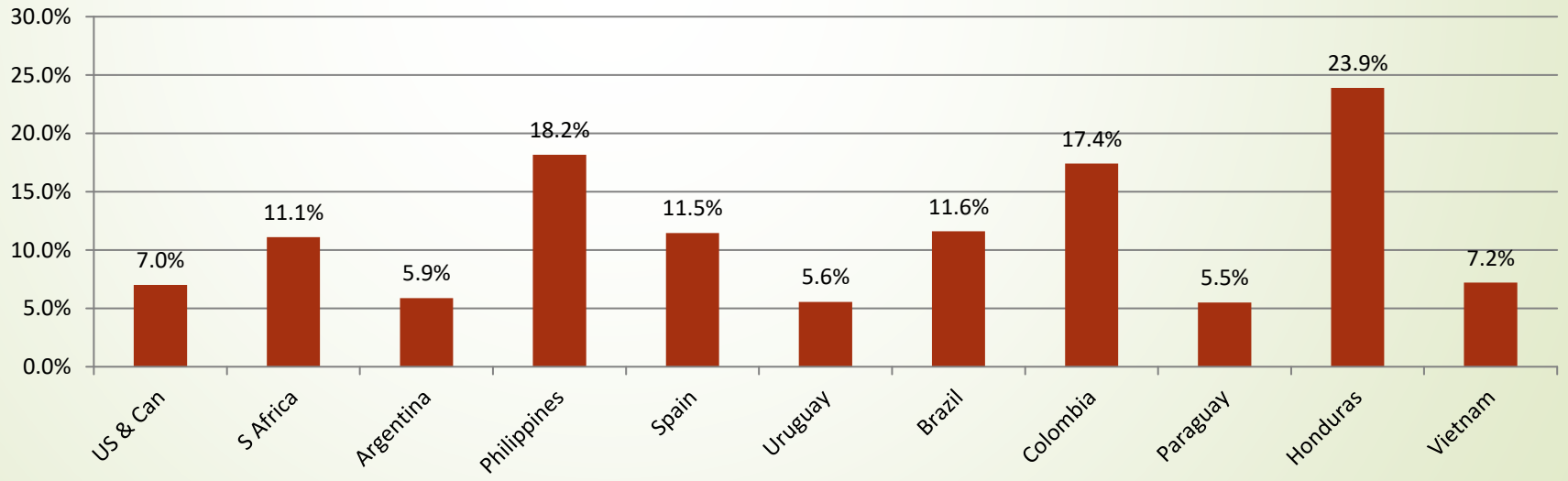
Yield gains versus cost savings

- 72% ($162 billion) of total farm income gain due to yield gains 1996-2018
- Remaining gains ($63 billion) from cost savings
- Yield gains mainly from GM IR technology (70%) and cost savings mainly from GM HT technology (90%)
- Yield gains greatest in developing countries and cost savings mainly in developed countries

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IR corn: average yield increase 1996-2018



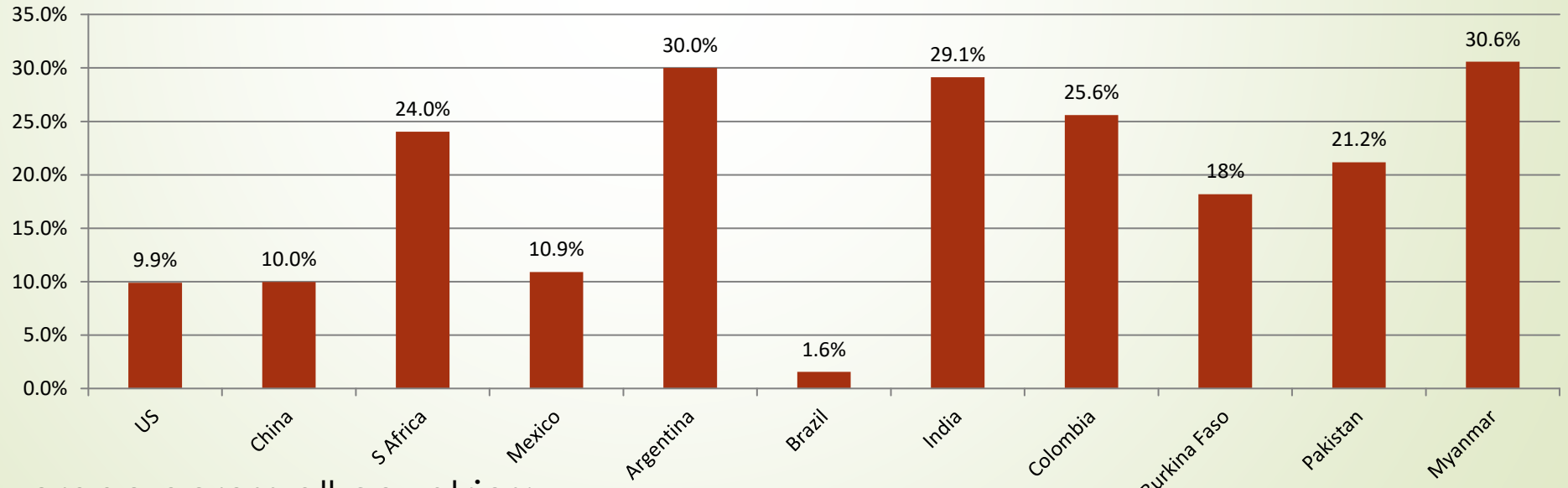


Average across all countries:
+16.5%

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IR cotton: average yield increase 1996-2018



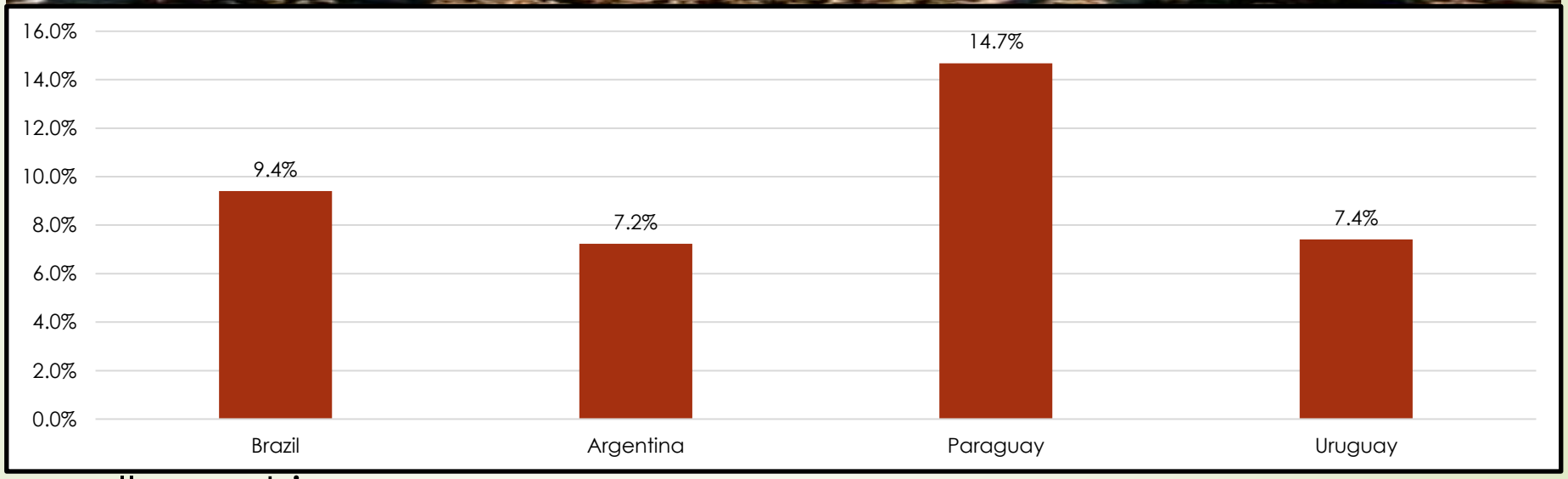


Average across all countries: +13.7%

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IR soybeans: average yield increase 2013-2018





Average across all countries:
+9.5%

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HT traits: yield and production effects

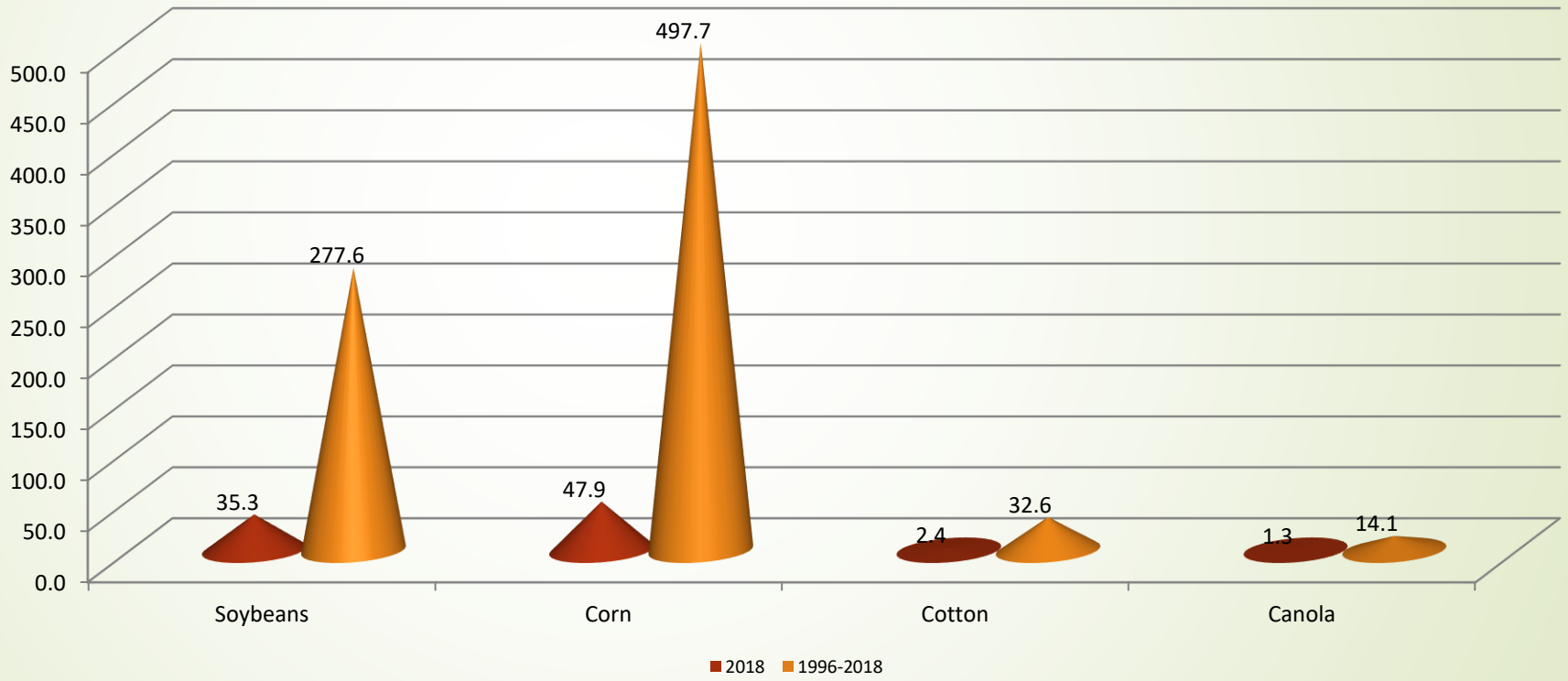




Trait/country	Yield/production effect
HT soy: Romania, Mexico and Bolivia	+23%, +5% and +15% respectively on yield
HT soy: 2nd generation: US and Canada	+9.3% yield
HT soy Argentina and Paraguay	Facilitation of 2nd crop soy after wheat: equal to +23% and +15% respectively to production level
HT corn: Argentina, Brazil, Philippines and Vietnam	+10%, +3.7%, 5.3% and +5% respectively on yield
HT cotton: Mexico, Colombia and Brazil	+13%, +3.6% and +1.6% respectively on yield
HT canola: US, Canada and Australia	+2.1%, +6.5% and +9.5% respectively on yield

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Additional crop production arising from positive yield effects of biotech traits 1996-2018 (million tonnes)



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Additional conventional area required if biotech not used (m ha)

	2018
Soybeans	12.3
Maize	8.1
Cotton	3.1
Canola	0.7
Total	**24.2** **equal to 38% of cropping area of Brazil**

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Impact on pesticide use

- Since 1996, use of pesticides down by 776 million kg(-8.6%, equivalent to 1.6 times annual pesticide active ingredient use on crops in China). Associated environmental impact (EIQ indicator)-19%
- Largest environmental gains from GM IR cotton: savings of 331 million kg insecticide use (-32%) and 35% reduction in associated environmental impact (EIQ measure) of insecticides

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Impact on greenhouse gas emissions



Lower GHG emissions:

2 main sources:

- Reduced fuel use (less spraying and soil cultivation)
- GM HT crops facilitate no till systems = less soil preparation = additional soil carbon storage

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Reduced GHG emissions: 2018

- Reduced fuel use (less spraying and tillage) = 2.4 billion kg less carbon dioxide
- Facilitation of no/low till systems = 20.6 billion kg of carbon dioxide not released into atmosphere
- Total 23 billion kg

Equivalent to removing 15.3 million cars — 48% of cars registered in the United Kingdom — from the road for one year



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Any negatives?

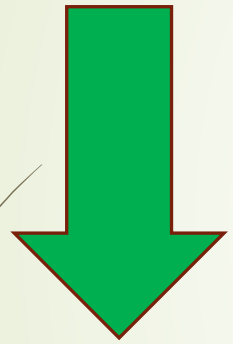
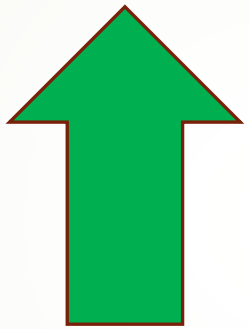
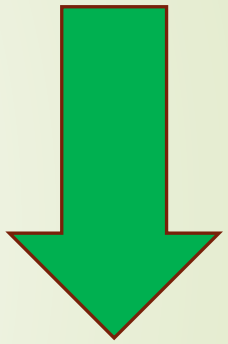
- Over reliance on glyphosate by some farmers in North/South America (with HT crops) contributed to weed resistance problems – farmers had to adapt and change weed control systems resulting in increased herbicide use and higher cost compared to 15 years ago

  BUT:

  - *Weed resistance problems and increased herbicide use also a trend in conventional crops*
  - *Environmental profile of herbicides used with HT crops remains better than equivalent on conventional crops*
  - *HT crops remain more profitable than conventional alternative*

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Summary of key global findings

Pesticide change 1996-2018	Global farm income 1996-2018	Global production 1996-2018	Carbon emission 2018
			
776 million kg reduction in pesticides (8.6%) & 19% cut in associated environmental impact	**$225 billion increase**	**824 million tonnes more food/feed/fibre**	**cut of 23 billion kg CO2 release; equal to taking 15.3 million cars off the road**

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Concluding comments

- ***GM IR technology***: higher yields, less production risk, decreased insecticide use, higher incomes, more reliable food supply, more environmentally-friendly farming methods
- ***GM HT technology***: higher incomes, extra production, facilitation of adoption of more sustainable farming systems (eg, no till), carbon emission savings
- ***Both technologies:*** important contributions to increasing world production of soybeans, corn, canola and cotton – results in less pressure to bring new land into agriculture
- **Newer traits**: drought tolerant (corn), fungal resistant potatoes and insect resistant (brinjal) now beginning to contribute positively

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Concluding comments

- After 23 years of widespread use – there is a considerable amount of **consistent** evidence in peer reviewed literature on the impact of GM crop technology
- This work adds to this literature
- Papers from this work available on open access at GM Food and Crops journal. http://www.tandfonline.com/toc/kgmc20/current
- I encourage you to read these papers and references cited in them and draw your own conclusions

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