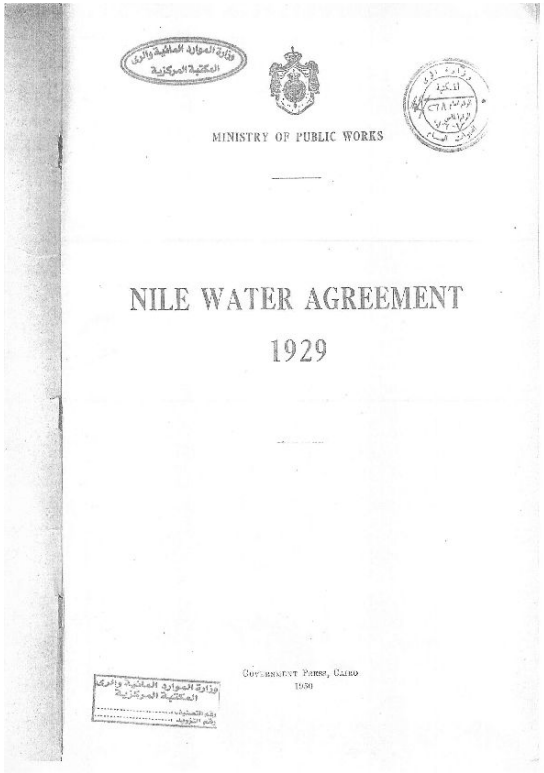
Egyptian Drought Resistant Cotton: A Solution to the GERD

PLNT 662

Natalie Warren, Fanfan Li, Neeraj, Ethan Coates, Harjot Kaur

The Nile and Water Agreements

https://www.researchgate.net/publication/338462628_Making_Water_Security_A_Morphological_Account_of_Nile_River_Development/figures?lo=1&utm_source=google&utm_medium=organic



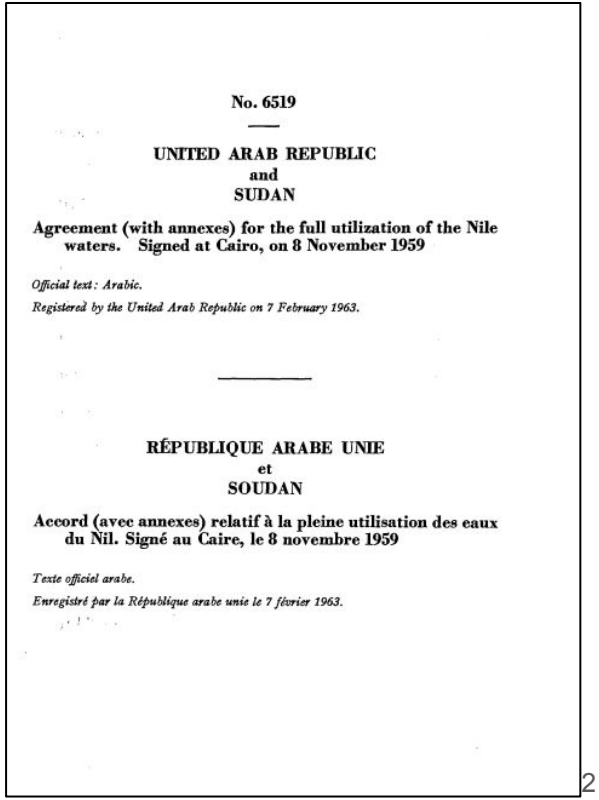
MINISTRY OF PUBLIC WORKS

NILE WATER AGREEMENT

1929

GOVERNMENT PRESS, CAIRO
1930

https://www.academia.edu/12727424/Nile_Water_Agreement_1929_



No. 6519

UNITED ARAB REPUBLIC
and
SUDAN

Agreement (with annexes) for the full utilization of the Nile waters. Signed at Cairo, on 8 November 1959

Official text: Arabic.

Registered by the United Arab Republic on 7 February 1963.

RÉPUBLIQUE ARABE UNIE
et
SOUDAN

Accord (avec annexes) relatif à la pleine utilisation des eaux du Nil. Signé au Caire, le 8 novembre 1959

Texte officiel arabe.

Enregistré par la République arabe unie le 7 février 1963.

https://treaties.un.org/doc/Publication/UNTS/Volume%20453/volume-453-I-6519-English.pdf

Grand Ethiopian Renaissance Dam (GERD)

https://www.dw.com/en/egypt-ethiopia-and-sudan-commit-to-resolving-nile-dam-dispute/a-51145011

https://www.atlanticcouncil.org/blogs/menasource/the-politics-of-water-what-we-know-about-the-grand-ethiopian-renaissance-dam/

Grand Ethiopian Renaissance Dam (GERD)

Impacts on Egypt

- Threat to water flow from the Nile
- Limit water for crop irrigation
- Limit agricultural production

Impacts on Ethiopia

+ Provide hydro power
+ boost economy pushing the country out of financial distress
+ platform to grow the nation
+ Prevent future food deserts

https://www.infoplease.com/atlas/africa/ethiopia-map

Senegal River Basin Development Organization

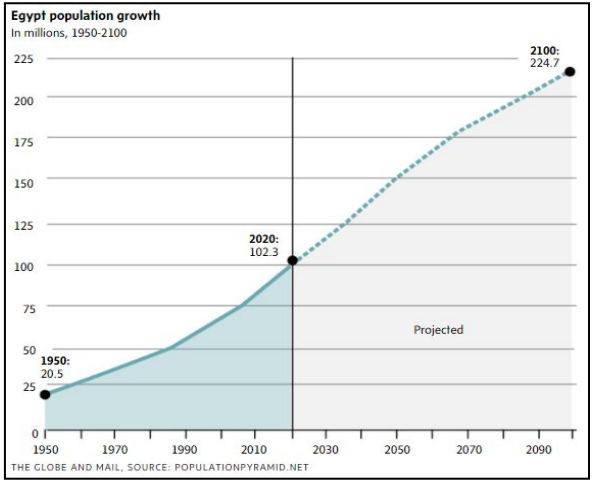
https://www.riob.org/en/incubation/Sharing-Satellite-Observations-Senegal-River-Basin

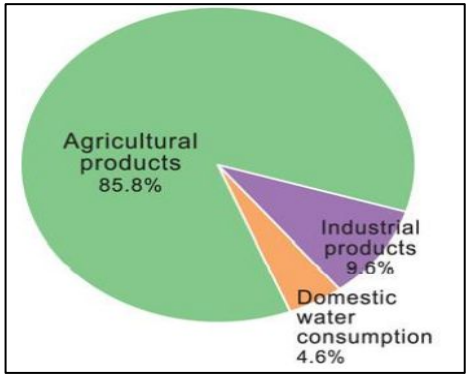
Problems

Renewable source of electric power
Seven water basins

Ethiopia

- Environmental issues
- Biodiversity, ecosystem and agriculture
- Technical issues
- Political issues
- Social issues
- Economic issues





GERD: a matter of life and death

Egypt

Sudan

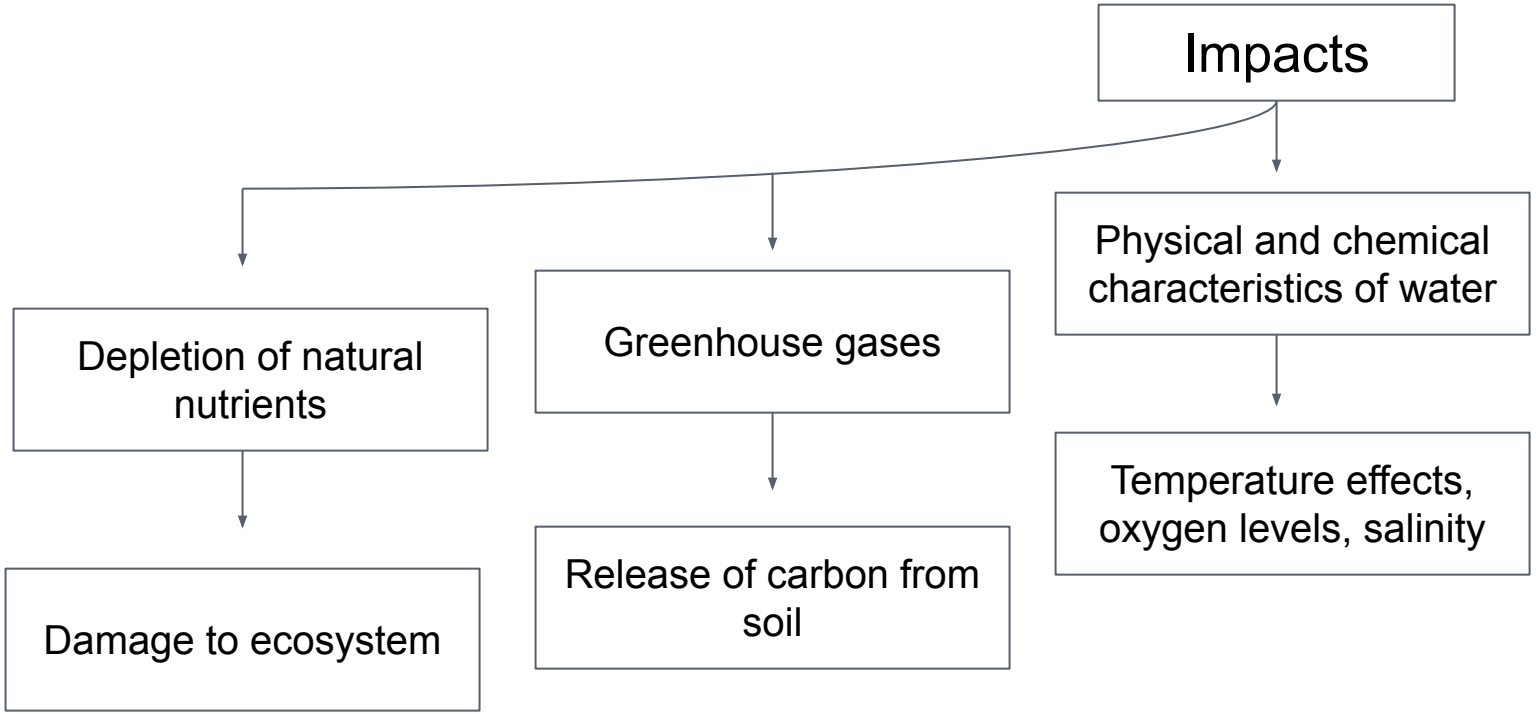
Classified as **water scarce country** by UN
NILE: only source of water
95% of Egypt's freshwater

National security threat

https://www.nilebasin.org/

UNESCO

GERD – The Grand Ethiopian Renaissance Dam



https://www.sciencedirect.com

El-Nashar, W. Y., & Elyamany, A. H. (2018). Managing risks of the Grand ethiopian renaissance dam on Egypt. *Ain Shams Engineering Journal*, *9*(4), 2383-2388.

Current efforts by Egyptian government

National Water Resources Plan, 2017
Investing $50 billion by 2037

Water Desalination
Investment of $2.8 billion to increase its desalination capacity by roughly 0.88 BCM/yr (billion cubic meters a year)

Wastewater Treatment
151 dual and triple wastewater treatment plants are being implemented across Egypt, at a cost of EGP 31.59bn

Omar and Moussa, 2016

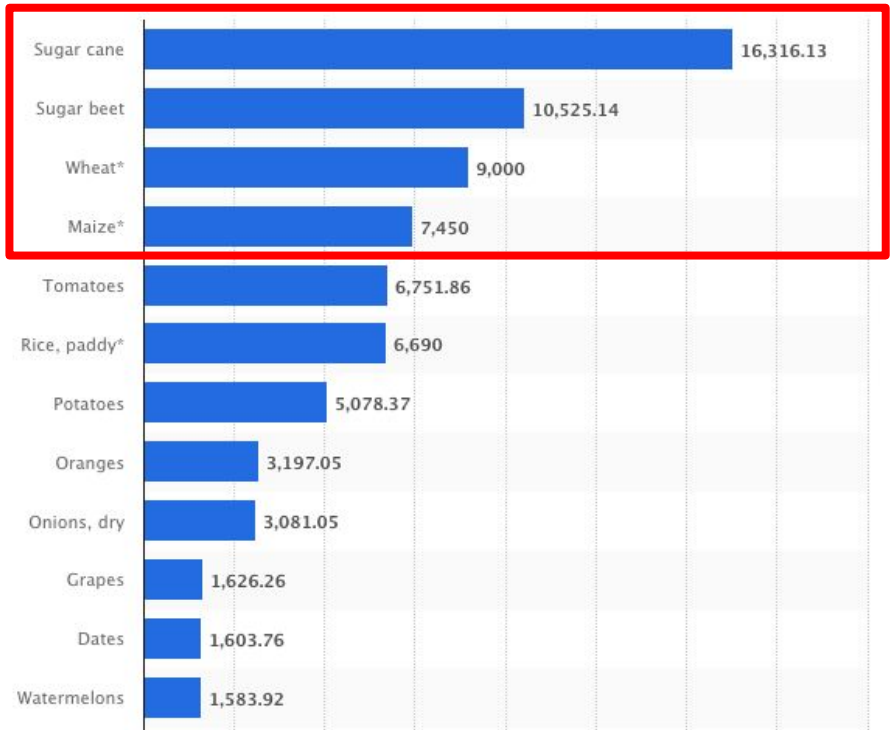
Current efforts by Egyptian government

- Covering the effective reaches of the 31,000 km of irrigation canals.
- Land leveling and irrigation at night..
- Regular inspection and maintenance of drip irrigation systems to eliminate any losses from damages.
- Turning the sprinkler systems to drip systems in many areas where the drip systems are more suitable. In general, water losses in drip systems are lower than sprinkler systems.

Reduction in the water loss rate from 15% to 5%.

Omar and Moussa, 2016

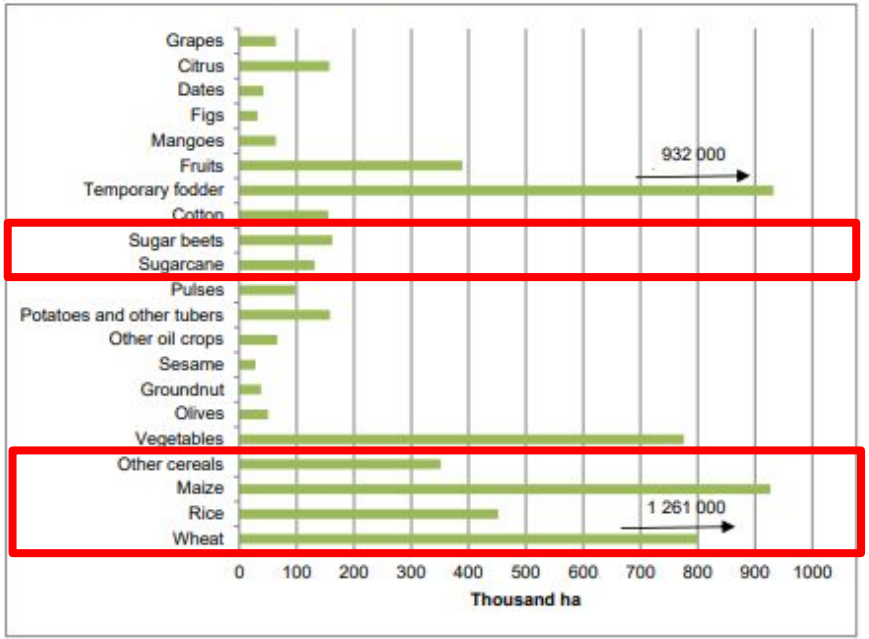
Egyptian Agriculture



https://www.foodbusinessnews.net/articles/15022-scientists-sequence-most-complete-sugarcane-genome https://ttseeds.com/product/sugar-beets/ https://www.world-grain.com/articles/16429-geopolitics-rain-in-plains-top-concerns-for-wheat-trad
https://phys.org/news/2017-08-genome-sequencing-maize-highlands-thousands.html e https://www.statista.com/statistics/1063560/egypt-main-crops-by-production-volume/

Water Intensive Crops

FIGURE 6
Harvested irrigated area
Total 6 333 000 ha harvested irrigated in 2010



Egypt’s Imports

Top 10 U.S. Agricultural Exports to Egypt
(values in million USD)

Commodity	2016	2017	2018	2019	2020	2019-2020 % Change	2016-2020 Average
Soybeans	100	364	1,164	995	1,475	48%	820
Dairy Products	29	35	30	45	77	69%	43
Feeds & Fodders	79	70	84	78	59	-24%	74
Beef & Beef Products	99	72	66	77	57	-26%	74
Tree Nuts	32	10	23	32	51	59%	30
Vegetable Oils*	51	48	34	31	37	18%	40
Cotton	34	36	55	31	28	-11%	37
Wheat	20	34	24	180	25	-86%	57
Soybean Oil	13	0	--	0	23	--	7
Corn	153	23	320	0	8	--	101
All Other	131	78	114	89	90	1%	100
Total Exported	741	770	1,914	1,558	1,930	24%	1,383

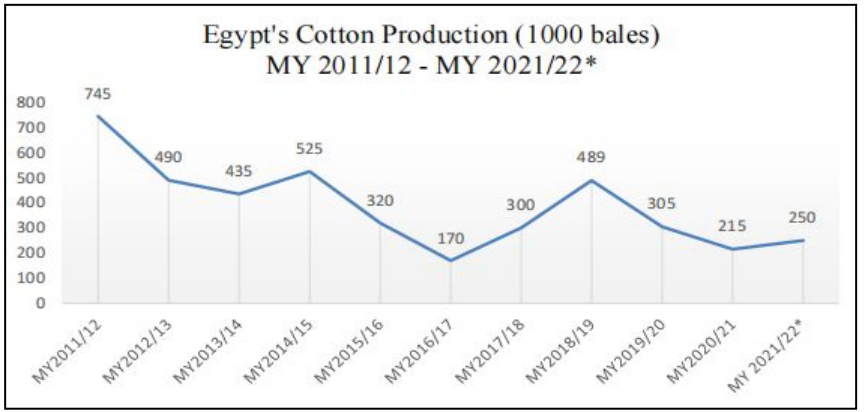
Import water intensive crops -> Invest in modifying Egypt's unique and world renown crops

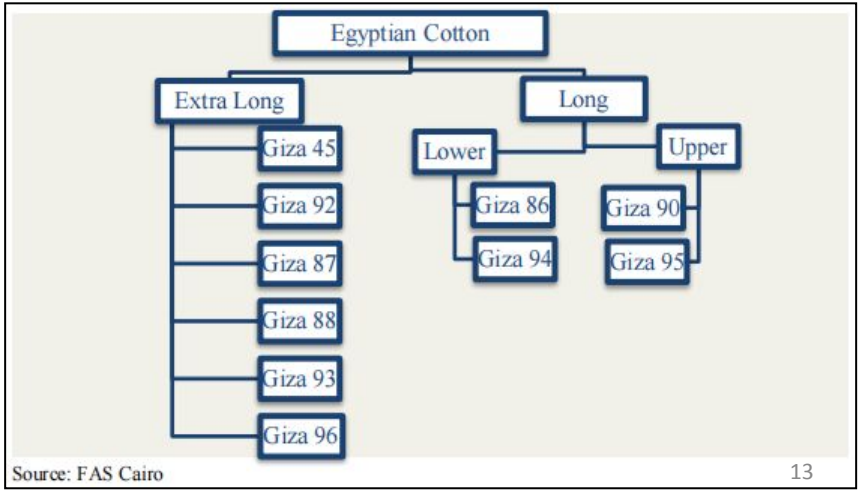
https://www.thearabweekly.com/egypts-white-gold-cotton-crop-suffers

Egyptian Cotton – the finest and renowned in the world

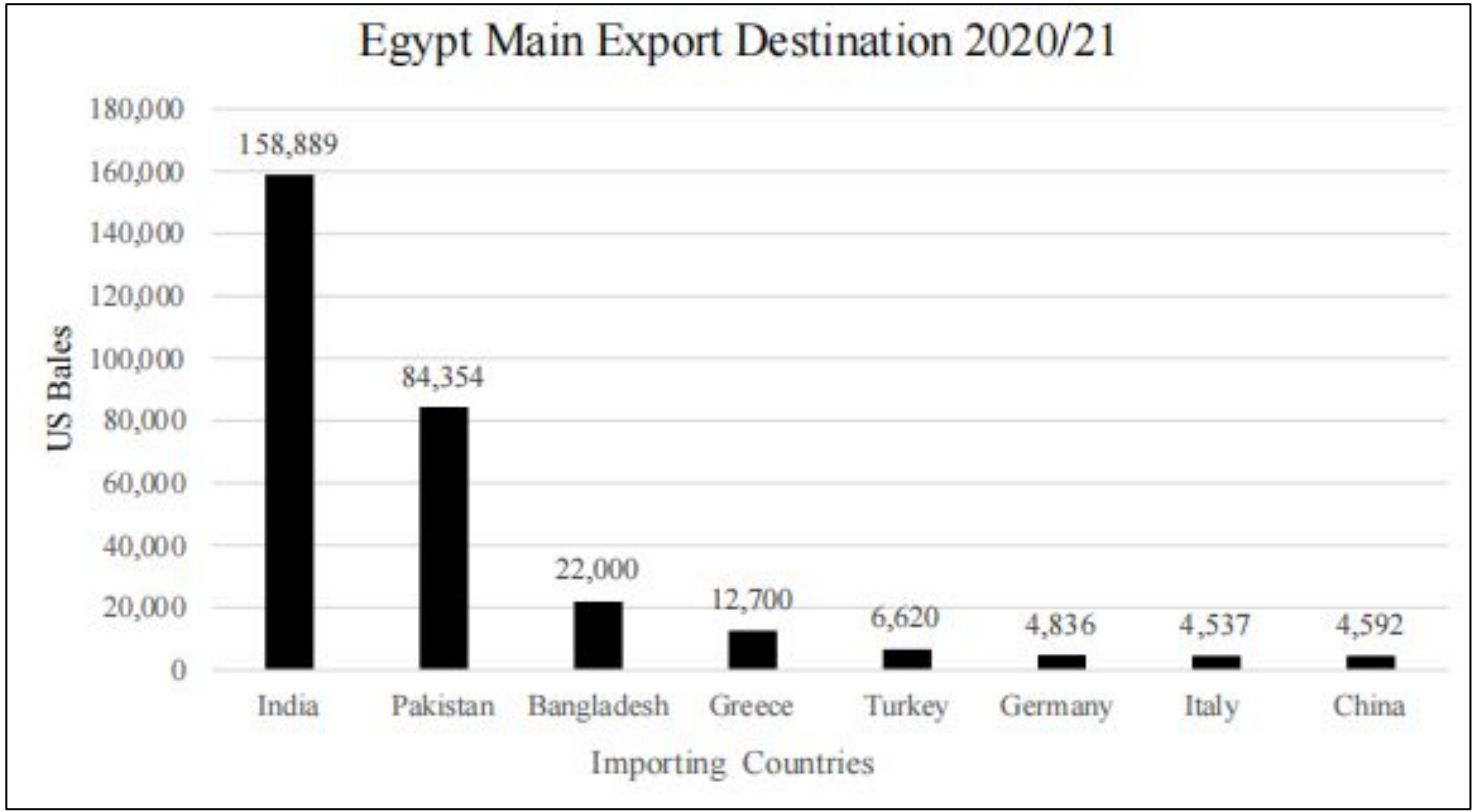
- Unique to Egypt
- Large export
- More fibrous
- Light weight
- Fine threads
- Long fibres
- High strength
- Soft and durable

EGYPTIAN COTTON™
CERTIFIED EGYPTIAN COTTON





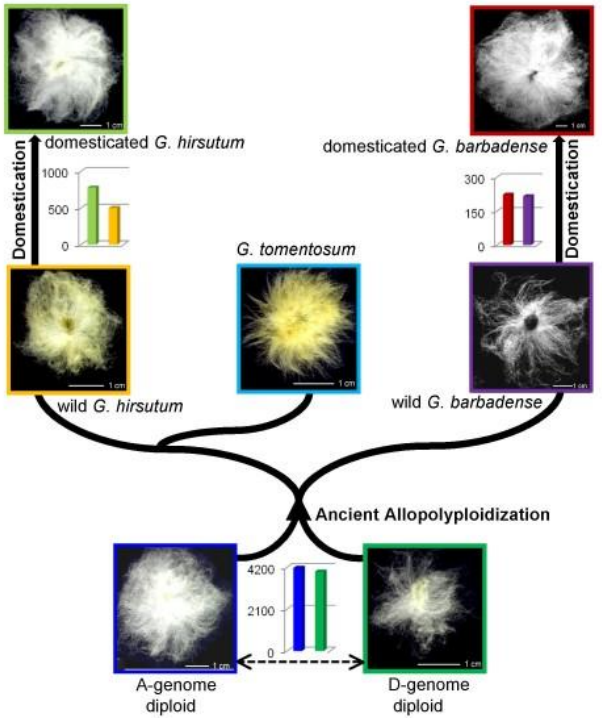
https://www.cottonegyptassociation.com/



USDA FAS, 2021

Considerations for engineering drought resistant cotton

- Gossypium barbadense has a long life cycle
  - 130 to 160 days from seed to harvest
  - Conventional breeding strategies are slow
- Gossypium barbadense is a tetraploid
  - Upwards of 4 copies of single gene
  - Creates difficulties using gene editing strategies such as CRISPR-Cas9



(Chaudhary et al. 2009)

Proposal to increase drought tolerance in cotton

- Transcription factors are an intriguing target to increase drought tolerance due to their involvement in many biological processes
- Previous studies have shown that transforming Arabidopsis with the transcription factor Hahb-4 (HB4) conferred drought tolerance (Manavella et al. 2006)

Normal conditions

WT HB4

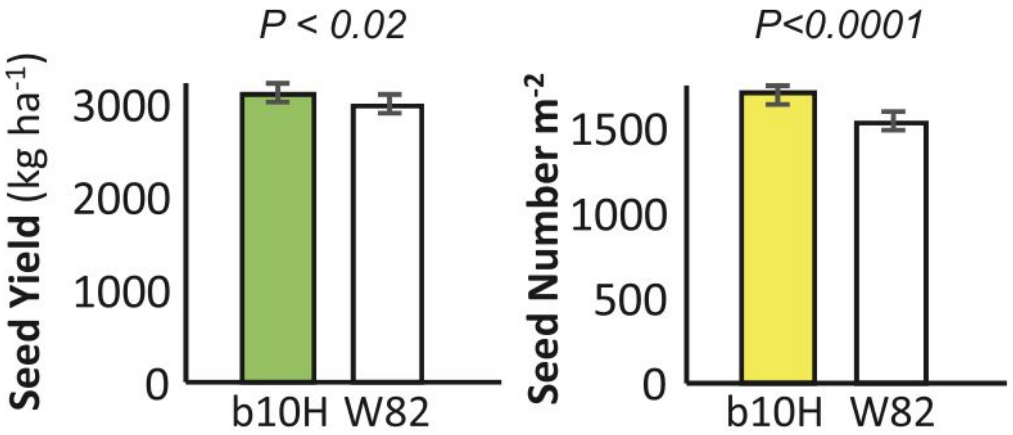
Drought Conditions

WT HB4

(Manavella et al. 2006)

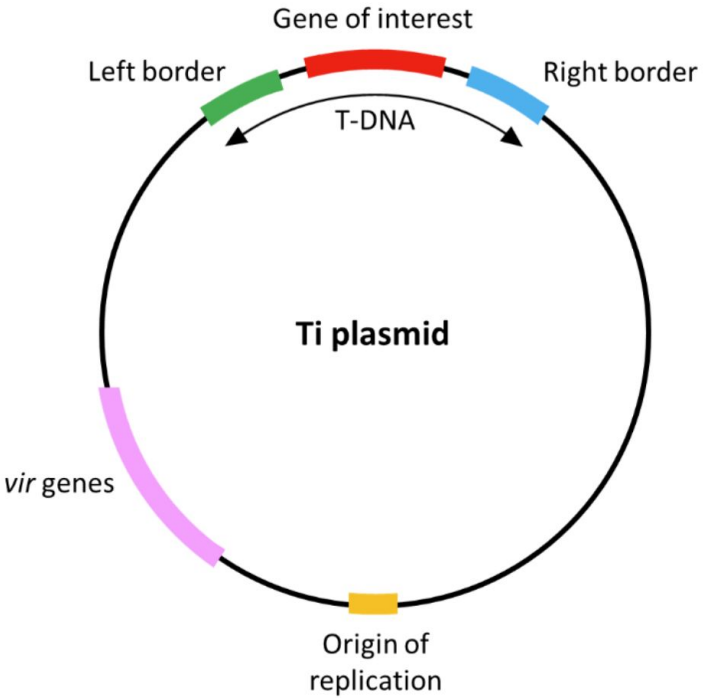
HB4 also confers drought tolerance in other species

- The native promoter of HB4 is inducible and only activated by water stress
  - There is no requirement for constitutive expression
  - No detrimental morphological differences under normal conditions
- Other plants species such as soybean has been successfully transformed with HB4 resulting in increased yield (Ribichich et al. 2020)



(Ribichich et al. 2020)

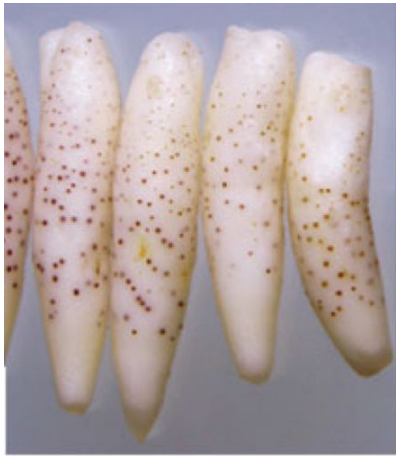
Stable Transformation via Agrobacterium

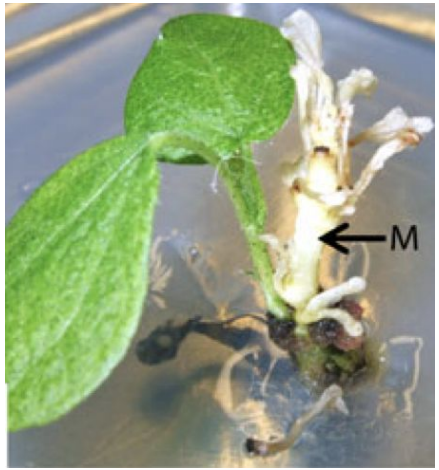


- Agrobacterium has the ability to transfer DNA from a plasmid to a plant's genome
- Requires virulence genes and correct border sequences flanking genes of interest
- Transfer DNA is inserted and integrated at a random place in the genome

Regeneration of a plant via tissue culture

- Tissue culture is the process by which agrobacterium infected explant tissue is regenerated into a complete plant by treating the tissue with specific phytohormones
- Typical starting explant tissue is petiole / cotyledons or hypocotyl tissue





Chen et al., 2014

GM crops regulations in Egypt

- Ministerial Decree 378 (March 8, 2012)

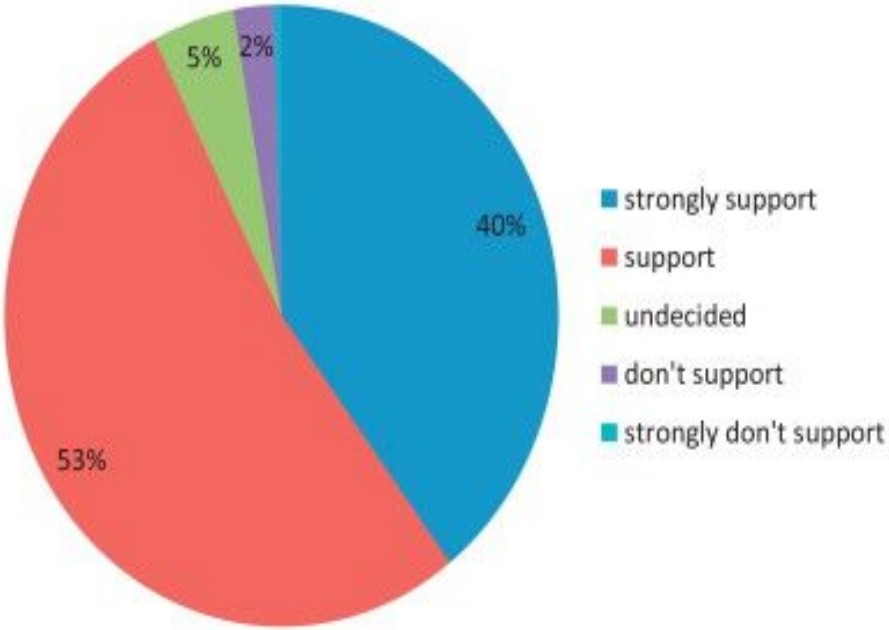
- Lack of commercial GM crop production

- No regulatory policy on the use of innovative biotechnologies such as genome editing using ZFNs, TALENs, and CRISPR/Cas9.

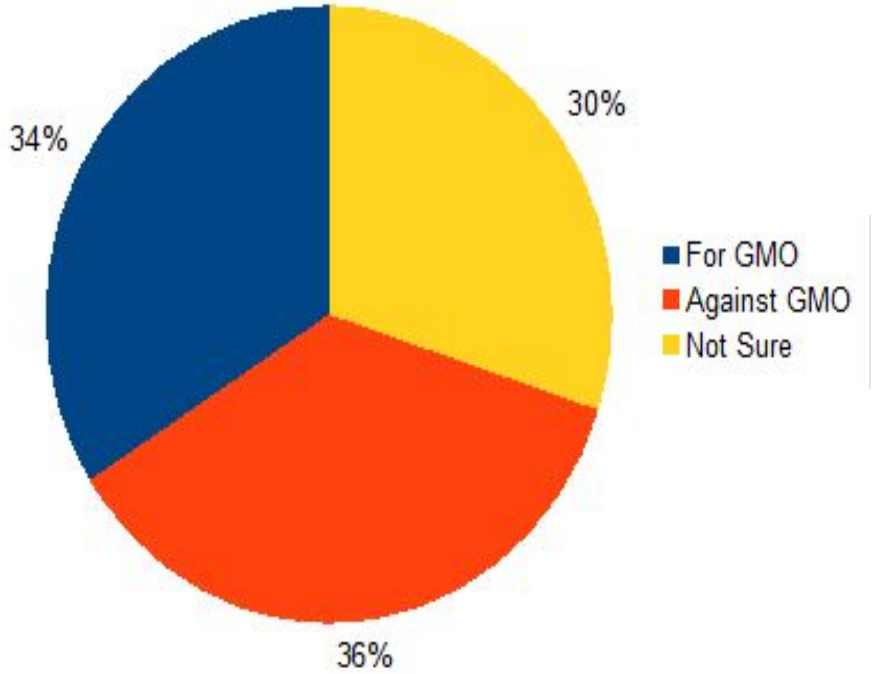
- Import of genetically-engineered products that are approved for and consumed in the country-of-origin, as well as are authorized for export is permitted

Turnbull et al., 2021

Perception to GM crops



Scientific community



Public

Malyska et al., 2014

Egypt’s Gene Editing Backlash

Campaigns by European environmental groups

Anti-biotech campaigns on social media.

Lack of communicating biotechnology to key Egyptian media organizations

Agricultural Biotechnology Report, 2017

https://www.shutterstock.com/search/thinking

Social Acceptance of Genetic Modification

https://uxwing.com/government-icon/

https://www.pinterest.ca/pin/social-media-icon-profile-social-media-smartphone-user-network-in-2021--814588651358127645/

https://www.dreamstime.com/education-icon-isolated-white-background-graduation-cap-simbol-flat-style-simple-abstract-place-icon-black-vector-image110069750

Owning Technology

Government Owned
Genetically Modified Crops

- Possible collaboration with industry
- Set prices
- Distribution of seeds each growing season

https://www.forbes.com/sites/charlesbeames/2021/09/30/it-is-time-our-government-stops-competing-against-the-commercial-space-industry/?sh=2698f4f22ae3

https://ttseeds.com/seeds-hybrid-open-pollinated-heirloom/

Summary

https://wwd.com/business-news/technology/giza-45-cotton-1203081908/

GERD and other environmental concerns have put immense pressure on Egypt's water supply

↓

Need for agricultural innovation

↓

Drought resistant genetically modification of unique and valuable crops such as cotton

↓

Agricultural and economic shift

Thank you!