GENE DRIVE ORGANISMS

An introduction to a dangerous new technology putting Africans at risk

etc GROUP

monitoring power
tracking technology
strengthening diversity

About ETC Group: ETC Group works to address the socioeconomic and ecological issues surrounding new technologies that could have an impact on the world's marginalized people. It operates at the global political level and works closely with partner civil society organizations (CSOs) and social movements, especially in Africa, Asia and Latin America. ETC Group is headquartered in Val David, Canada, and Davao, Philippines, with offices in Mexico City and London, UK.

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Overview

The belief that new technologies will provide the main cure to humanity's problems is increasingly common across the globe. From industrial agriculture, where proponents of genetic modification argue that new altered crops can help feed the world, to digital healthcare, where some propose artificial intelligence and robotics to prevent people needing to see a doctor. Even some people who claim to be furthering biodiversity conservation express their faith in hi-tech solutions, such as the deploying remotely controlled drones and satellite imaging to monitor endangered organisms.

It seems that powerful individuals and organisations have an almost blind faith that we can live better, more comfortable, and more efficient lives by embracing every new technology under the sun, regardless of who developed it, who profits from it and what the real motivations and potential consequences might be. They define advanced society as one that embraces technological innovation, while labelling those who ask questions and adopt a critical position toward certain technologies as 'anti-development.' However, many new technologies come with serious potential risks. When developed by powerful groups, such innovations are initially designed to make a profit, rather than to improve social or ecological conditions in the world. These technologies may have the effect of exerting greater control over, or even harming, society and nature.

One such technology is the gene drive organism (GDO), dubbed by critics as an 'exterminator' technology. GDOs are created by genetically engineering a living organism and then modifying the sexual system of reproduction to force modified genes onto future generations so it spreads through the whole of a population. Unlike earlier biotechnology inventions, GDOs threaten to take the process of genetic engineering from something intended to be contained in a laboratory to a process that deliberately spreads those engineered changes throughout the environment. Should this be technically effective, the consequences are completely unknown and could be devastating to ecosystems, agriculture and other life support systems.

GDOs are built to intentionally spread their implanted traits through an entire population and could easily be designed to cause a whole species to become extinct or replaced. So far this 'exterminator technology' has never been tested in a natural, or even semi-natural environment but the day of GDO release is coming. Its supporters already claim they have the right to release GM mosquitoes as a first step towards later releasing gene drive mosquitoes in a rural area of Burkina Faso. This first step of the process could potentially be starting in 2019 or 2020. There also reports of plans for releases in the near future in Mali, Uganda, Ghana and Côte d'Ivoire.

Experimenting with extinction technology in this way is risky. The planet is already facing a wave of extinctions of both animals and plant species, the speed of which is unprecedented in human history. A global scientific review reports that almost half of all insect species have become extinct over the last thirty years. This has already had disastrous impacts on the rest of the web of life, including reptiles, birds, amphibians and many other animals and plant species. The impact of this current decline could, according to leading researchers, result in a "catastrophic collapse of nature's ecosystems."[1]

Given the gravity of this crisis, and the potential for GDOs to create an additional chain-reaction of multiple extinctions, it is urgent that civil society groups, faith networks, activists, lawyers, scientists, journalists and young people acquire a thorough understanding of the technology. Together we must make the case against unleashing yet another unregulated industrial technology on our ecosystems, this latest one being deliberately designed to make species go extinct.

[1] Damian Carrington, "Plummeting insect numbers 'threaten collapse of nature,' The Guardian, 10 February 2019, https://www.theguardian.com/environment/2019/feb/10/plummeting-insect-numbers-threaten-collapse-of-nature

A brief guide to GDOs

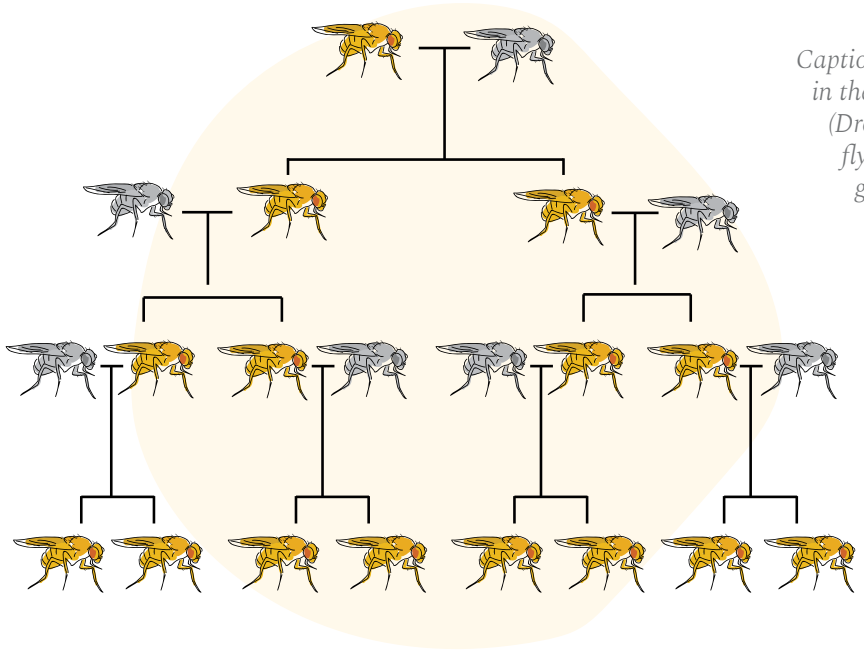
What is a Gene Drive Organism?

A gene drive organism (GDO) is a new experimental technology designed to aggressively spread particular genetic traits[2] through an entire species or population. Gene drives have currently only been developed in sexually reproducing animals and insects but could potentially be introduced into some plants and microbes, such as yeast. In the biology of normal sexual reproduction, any given trait has a 50:50 chance of being inherited by the offspring in a species. GDOs are designed to ensure that a genetic trait is preferentially forced onto subsequent generations. In this way, all offspring of a particular population and potentially the entire species, could inherit that trait.

This potentially unstoppable process of driving genes into a whole population has been called a 'mutagenic chain reaction.' Similar to nuclear chain reactions, a runaway mutagenic chain reaction could cause a melt-down for biological diversity.

In French, the process is called 'forçage génétique' ('genetic forcing') which more accurately describes the process of forcing traits from one generation to the next and eventually onto a whole species.

GDOs have been dubbed by critics as an 'exterminator technology.' This is for two reasons. First, it appears that the designers of the technology actively intend for GDOs to be used to eliminate species considered undesirable. Second, because some seemingly distinct species interbreed in the wild causing genes to be transferred between them, it is possible that so-called non-target species (species other than those intended) could also be threatened with extinction. If such gene transfer took place, genetic changes could spread rapidly among similar insect species. By following the logic of their inventors, GDOs are potentially a technology of mass-extinction for insects and other organisms.

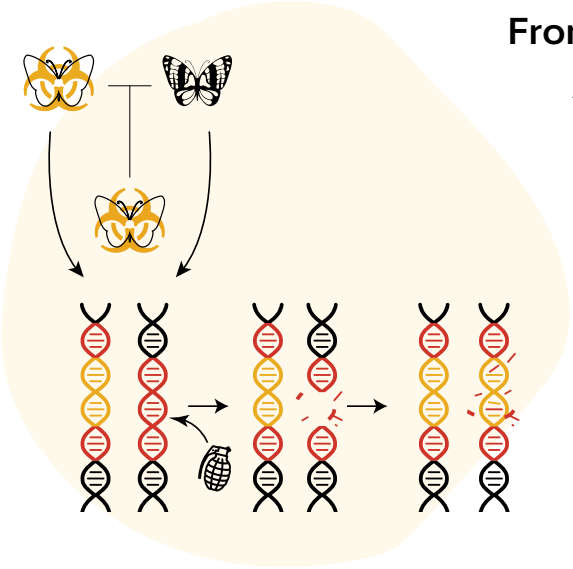


Caption: One of the first GDOs to be invented in the laboratory was a gene drive fruit fly (Drosophila). The gene drive forced the fly's reproductive system to transmit the gene for yellow colour onto subsequent generations. If the yellow fly containing the gene drive mechanism were to be introduced into a population outside the laboratory, the yellow trait could spread and eventually all the related flies born in the wild could, according to gene drive researchers, become yellow.

[2] A trait is a genetically determined characteristic

HOW DOES IT WORK?

Gene Drives turn sexual selection, natural selection and potentially even the process of evolution on its head by artificially forcing a chosen genetic modification through entire populations. The most well-known gene drives have been created using a recently-developed genetic engineering technique called CRISPR[3]. Part of a family of techniques dubbed 'gene editing' by their proponents, CRISPR uses enzymes (biological chemicals) to cut DNA in an organism and then make changes to DNA. The GDOs created so far use CRISPR to cut open DNA and insert a gene editing capability right into a natural organism's DNA on one of two sets of chromosomes (one set from each parent) during the process of reproduction.[4] This CRISPR mechanism now starts making the enzymes that cut the DNA in the chromosome from the other parent. In effect, the parent organism genetically engineers the child. From there, CRISPR induces the cell to copy the package of genetic traits onto the matching chromosome so that the organism will definitely pass it on to its offspring and start the forcing process again. The genes for the desired trait, such as yellow colouring, are built into the CRISPR gene-forcing mechanism that gets passed forward to the next generation. In this way, each parent genetically engineers its own child and the gene is copied forward into an ever-increasing proportion of the population with each successive generation.



From GMO to GDO – A Bad Idea Gone Worse

A gene drive made by gene editing is a type of genetic modification, also called 'genetic engineering.' This is not the old-school GMOs like corn, soy and cassava brought to you by biotechnology companies that have spent the past three decades genetically manipulating plants, animals, microorganisms and insects. Those are bad enough, in part because they run the risk of accidentally spreading their modifications to unintended crops, plants and populations. Gene drives are genetic modifications designed to spread deliberately, changing not just one crop but an entire species. Gene drives are population-scale genetic engineering.

Caption: In organisms that inherit one drive-containing and one wild-type chroosome, the drive cuts the wild-type chromosome, causing the cell to copy the drive when it uses the drive-containing chromosome as a template to repair the damage. Because it now has two copies of the drive (and whatever alteration the drive is spreading), all the organism's offspring will inherit a drive-containing chromosome to repeat the process.

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[3] See Dr. Janet Cotter and Dana Perls,, "Gene-edited organisms in agriculture: Risks and unexpected consequences," Briefing Paper produced by Friends of the Earth US and Logos Environmental, 2018, p. 7, https://foe.org/news/new-report-gene-editing-agriculture-poses-new-risks-health-environment/

[4] A chromosome is a thread-like structure that is found in the nucleus of a cell and carries DNA (the genetic code of an organism)

What is the difference between GMOs and New GM?

The actual techniques used to make gene drives, such as CRISPR, belong to a new category of genetic engineering techniques being pushed by the biotechnology industry under the broad term 'synthetic biology.' 'Classic' genetic engineering would cut out segments of DNA from one organism and paste it into the DNA of another organism to give it a particular trait. These 'New GM' (or GMO 2.0) approaches attempt to change the biology of living organisms by making small cuts and artificial DNA designed by computers. Synthetic biologists try to design and construct new biological parts, devices and systems that do not currently exist in the natural world – that is, making artificial human-made DNA.

These techniques have given rise, now, to many possibilities – from creating products such as yeast grown fake vanilla flavour in a factory to gene drive organisms, which genetically manipulate the living world outside of the factory. However, all these application have the same end – to further concentrate control of resources and production, particularly in agriculture. Experiments are still largely limited to the laboratories of Europe and North America, but the scientists' plans are to do the GDO field trials somewhere else – namely. Africa.

Another example of synthetic biology that does not involve gene drives is tweaking the genetic instructions of brewer's yeast to synthetically produce a vanilla flavor (by Swiss company Evolva). This may sound like a clever trick but it could also put at risk the livelihoods of thousands of people who produce natural vanillin in countries like Madagascar, Comoros, Réunion, Tanzania and DRC.

Madagascar is one of the world's largest producers of vanilla. It takes time to grow vanilla. With synthetic biology, companies don't need to come and buy those products from the farmers, all they need to do is produce them. With vanilla you need to watch it like a baby, it grows in the forest. In that case, the farmers take care of the forest so it can take care of their vanilla. If they no longer grow their vanilla, they will cut down the forest, a lot of things will go; economics will be threatened, the forest will go down because they have to plant other crops that might not necessarily need them to take care of the forest. These people will be displaced and are going to displace other farmers. We don't even know the attendant impact that it will have on the environment and especially on biological diversity.

– Mariann Bassey, Friends of the Earth Nigeria

Money behind the Madness:

Gene Drive Experiments on Africa and throughout the World

There is a lot to learn about the motivations behind the development of these experimental and risky technologies by following the money. Who is funding these projects and why?

A) Weaponizing Nature

GDOs are a 'dual use' technology. This means that it is possible to use gene drive technologies for an additional purpose to the one for which they were invented. For example, gene drive yeasts created in the lab could be engineered to be harmful to humans. In this case, GDOs could become biological weapons. An engineered gene drive released into agricultural fields to weaken plants or destroy pollinators could be hijacked to attack a country's food production. Flying insects like gene drive mosquitoes and other insects could theoretically be engineered to spread lethal toxins in their bite.

Total funding for GDO development is currently estimated to exceed a quarter of a billion US dollars. The largest single government funder of gene drive research is the U.S. Defense Advanced Research Projects Agency (DARPA) which either directly funds or co-ordinates with almost all major players working on gene drive development as well as the key holders of patents on CRISPR gene editing technology. DARPA also funds work on gene drive insects for Africa. There is also a high level of interest and activity by other sections of the US military and intelligence community in GDOs since it is recognized that gene drives could be used as weapons.[5]

The relationship between industrial agriculture technologies and the military is not new. One of the most infamous examples is the agricultural herbicides and defoliants such as Agent Orange that the United States used as chemical weapons against Vietnam in the 1960s. These chemicals were manufactured by some of the same companies that evidence suggests are exploring gene drive organisms today, such as Monsanto (now Bayer-Monsanto).

In 2017, a classified study on gene drives was undertaken by a secretive US Military group, JASON, to understand the "potential threats this technology might pose in the hands of an adversary." The international Bioweapons Convention has also been exploring the dual use implications of this technology. DARPA has contributed 65-100 million US dollars to some of the highest profile gene drive developers under a project called 'Safe Genes.' Safe Genes explicitly acknowledges that gene drives pose 'bio-threats' from "irresponsible actors who might intentionally or accidentally release modified organisms."

B) Mega-corporate Agriculture

In order to build sympathy and support for the development of GDOs, promoters present a vision of huge numbers of potential applications in health and conservation. However, one of the real motivations, revealed in private and through patent applications, is to use these technologies in agriculture.

Reports from secret meetings with the US government defense committee mentioned above show that agribusiness firms such as Bayer-Monsanto and Cibus Bioscience appear to be engaging with GDO development. If they start to adopt GDOs then the way we feed ourselves and the ways in which small scale producers feed us could be fundamentally transformed. Other

[5] More information is available at the Gene Drive Files, a repository and analysis of Freedom of Information Act requests undertaken in 2017: http://genedrivefiles.synbiowatch.org/

global agribusinesses including Syngenta and Corteva Agroscience have been closely involved in US gene drive policy discussions. There is also a private start-up company Agragene which "intends to alter plants and insects" for agriculture using gene drives. Agragene is joined in its ambition by crop commodity groups like the California Cherry Board and the US Citrus Research Board. A key industrial agricultural lobbying firm, Emerging Ag Inc., received 1.6 million US dollars from the Bill and Melinda Gates Foundation to lead lobbying and communication activities to promote gene drives and influence UN meetings, including the creation of a 'Gene Drive Outreach Network.' Emerging Ag also administers the World Farmers' Organization – a well-known lobby group for agribusiness that operates at the United Nations.

Example 1: Making Africa's most nutritious green crop vulnerable to Roundup

Herbicide resistance in weeds occurs when weeds selectively evolve to withstand higher doses of chemical herbicides after repeated exposure to those chemicals. One of the most common herbicide resistance challenges is the development of resistance to Roundup (glyphosate), Bayer-Monsanto's popular weed killer. In the US, resistance to Roundup is spreading in weeds such as pigweed (also known as Amaranthus palmeri, ragweed or water hemp). Much has been written about the idea of introducing a gene drive into pigweed to make it susceptible to Roundup again. This type of gene drive would allow the manufacturer of the compound (Bayer-Monsanto in this case) to sell their proprietary chemical matched to the wild weed species. Whereas Bayer-Monsanto previously made its crop seeds 'Roundup Ready' (that is, resistant to glyphosate) to boost glyphosate sales, now the idea is that the weed itself becomes 'ready' to wilt in response to Roundup. When weeds are not totally eradicated, they may again evolve to become resistant to the herbicide. In such a situation, the gene drive is only a temporary solution and may have to be re-released repeatedly. Glyphosate itself is a highly dangerous chemical and was found to be implicated in the collapse of honeybee pollinators which are incredibly sensitive to small amounts of the poison. Glyphosate has also been named as a probable cause of cancer by an international expert body and in multiple US court cases, with the most recent resulting in a 2 billion dollar judgment against the company. If glyphosate is restricted in the US and Europe, which very well may happen now, the company could start dumping the poison on the global south, including Africa.

However, Bayer-Monsanto's weed is Africa's most nutritious green. What is defined as a weed in one place is an important cultural food in another: while pigweed is seen as a weed by industrial farmers in the US, in Africa it is a common food crop found across the continent and goes under names such as 'bbuga' and 'dodoo' in Kenya and Uganda. The Botanical Society of South Africa considers it "Africa's most nutritious leaf vegetable." If a gene drive to alter pigweed were accidentally or intentionally released on the African continent it could have serious impacts on food security.

Example 2: Driving Insects to Extinction

The larval stages (often called worms) of many moths are considered pests of cultivated plants and crops. Scientists at the French government's National Institute for Agricultural Research (INRA) labs have reported demonstrating that the CRISPR-Cas9 system is highly efficient for genome editing in the African cotton leaf worm Spodoptera littoralis. This species has been labeled as a quarantine pest by the European and Mediterranean Plant Protection Organization and has also been listed as a highly invasive species in the United States. Once this process has succeeded in one moth species, it will be easier to adapt the technology for other moth pests such as the gypsy moth, the larvae of which consume the leaves of more than 500 species of trees, shrubs and plants in Africa and other areas of the world. Another team at UC Irvine propose using gene drives to control the Fall Armyworm (Spodoptera frugiperda). As the world is becoming more aware of the catastrophic implications of mass species extinction, particularly among insects, the idea of driving African insects to extinction to protect US and Western interests is a further expression of the short-sighted colonial mindframe behind these proposals.

C) Extinction Masquerading as Conservation

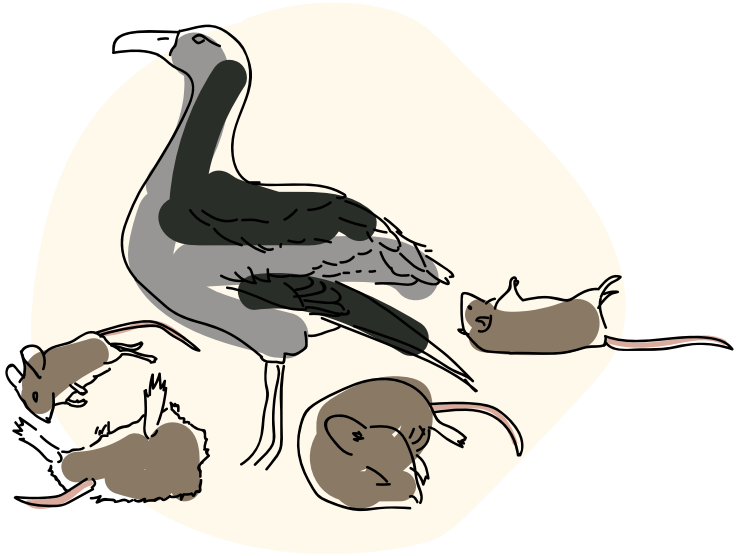
Some proposals for GDOs claim that the technology will have conservation benefits such as eradicating invasive species. These applications are rooted in a larger framework in which simplistic technological fixes are applied to problems that have their roots in more complex social, cultural, legal and economic causes. The introduction of invasive species could have resulted from a variety of factors including many that are the result of unequal power dynamics, such as trade policies, the exclusion of traditional communities from their ancestral lands, the unsustainable use of biodiversity by industrial actors, and the imposition of industrial agriculture.

Example: GBIRd

A small group of northern conservationists argue that GDOs designed to cause deliberate extinction can be harnessed for good. A consortium of five partner organizations (including two government agencies in the US and Australia) led by a group called Island Conservation is developing a project called GBIRd (Genetic Bio-control of Invasive Rodents). Island Conservation's mission is to prevent extinctions of island species by removing invasive species. The GBIRd project aims to preserve island species such as seabirds (whose chicks and eggs are attacked by mice) by releasing gene drive mice that will cause subsequent generations of mice to be single sex, eventually wiping out the entire species. They had indicated an intent to release these GDOs by 2020 but now this looks unlikely. Almost all GBIRd's funding appears to come from the US Military agency, DARPA.

D) Experimenting on Africa – hyping benefits to health

Promoters of GDOs claim that, alongside conservation, public health is a sector that could benefit from GDO development and release. The most high-profile promises made for GDOs involve



proposals to suppress or eliminate species that carry human and animal diseases. Vector-borne diseases such as Malaria, Dengue, Zika, sleeping sickness, Lyme Disease or Schistosomiasis are typically carried by biting insects, mites or animal pests, such as mosquitoes, ticks and rats. Geneticists are experimenting with gene drives that will engineer these host organisms to disrupt the disease transmission cycle or just eradicate them completely. Some GDO projects, for example those run by the Target Malaria group of Imperial College in the UK, attempt to suppress or eradicate natural mosquito populations that carry malaria. Others, such as work by Anthony James of UC Riverside, attempt to engineer mosquitos so they are unable to carry the malaria parasite, or to make vector insects become repelled by human scent. GDOs could potentially also be developed to combat diseases that primarily affect wild or domesticated animals (for example eliminating Cochliomyia, the New World screwworm, which afflicts cattle).

> *"Africa is a testing ground for technologies that have not been tried anywhere else... When these people bring them here, they made them sound like this is the best that can ever happen to the continent, but then they don't show them the negative side effects. Anything that cannot be done in the US or in Canada or in other western countries, why should it be done in Kenya or in Uganda?"*
>
> *– Bior K Bior, Scientist and Founder of the Nile Initiative for Health and Environment, South Sudan.*

Timeline of African's history with GDOs & GMOs

1973
First genetically modified (GM) organism created from a bacterium

1974
First GM animal created from a mouse

1982
First GM insect created from a fruit fly

1983
First GM plant created from a tobacco variety.

1995
First GM cassava plant created

1998
South Africa authorises the first GM crops in Africa

2008
Bt Cotton introduced to Burkina Faso

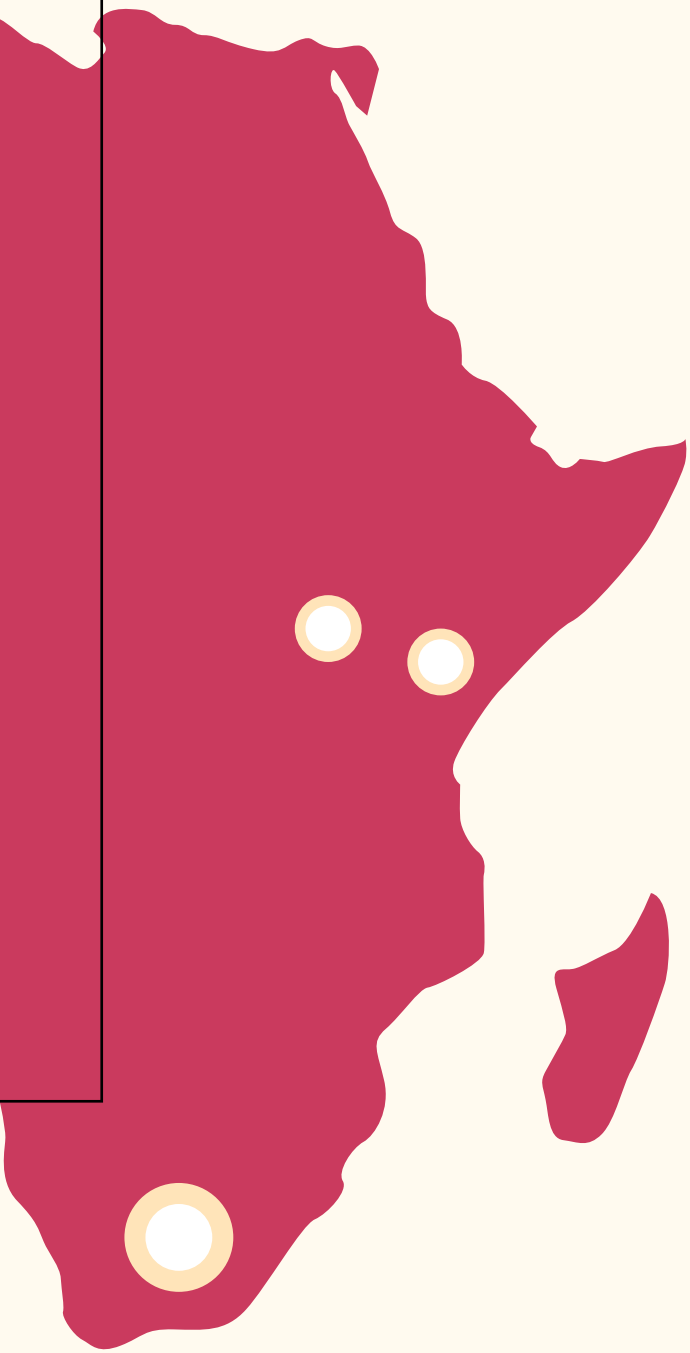
2012
Invention of CRISPR-CAS9 process by Jennifer Doudna and Emmanuelle Charpentier

2013
California Cherry Board (a group of fruit producers) funds the development of gene drive in the spotted wing fruit fly Drosophila suzukii by Omar Akbari and others.

2014
Gene drive conferring a yellow colour on a Drosophila population is invented. Inventors join Akbari to form Agragene, a commercial company to exploit GDOs in agriculture.

2014

Kevin Esvelt warns fellow GDO researchers about potential impacts of gene drives in nature while also filing first patent on RNA-guided gene drive.



2016

Over 170 organisations call for a moratorium on technical development and experimental application of GDOs.

US National Academy of Science, Engineering and Medicine publishes 'Gene drives on the Horizon', warning of dangers of irreversible effects of GDOs

Thirty environmental leaders reject the use of GDOs in conservation initiatives

The US Government's defence research agency (DARPA) invests $65 million on 'safe genes' (research related to gene drives).

Gene drive mosquitos for malaria control proposed by Target Malaria for introduction in Burkina Faso, Mali, Uganda, Kenya and Ghana.

2018

African Union's NEPAD publishes policy report supporting use of GMO and GDO mosquitos.

Over 250 organizations call for a global moratorium on the environmental release of GDOs.

United Nations agrees to controls on GDOs under its Convention on Biological Diversity.

2019

Target Malaria releases first genetically modified insect in Africa (GMO Mosquito in Bana, Burkina Faso)

OXITEC'S GENETICALLY MODIFIED MOSQUITOES

Oxitec is a UK based company that produces GM mosquitoes with the declared aim of tackling malaria and other mosquito-borne disease. The company modified the males of a mosquito species Aedes aegypti, which carries dengue, zika and chikungunya, so that the offspring of the species would die as larvae and would not survive into adulthood to reproduce. Oxitec conducted open field releases of these modified mosquitoes in the Cayman Islands, Malaysia and Panama. Although the company claimed that its trials were 80-90 percent successful in reducing the mosquito population, Freedom of Information Act requests revealed that the female mosquitoes that transmit dengue had in fact increased in one of the areas where the trials took place.[6] In November 2018, the government of the Cayman Islands announced that all genetically modified mosquito trials had failed and were canceled; the government claimed that the experiments were expensive and did not result in a decrease of mosquitoes. While Oxitec's mosquitos are not themselves GDOs, the founder of the company has now moved on to focus on GDOs.

Example: Target Malaria

Target Malaria is a GDO research consortium led by Imperial College in London, which is developing Gene Drives for malaria control. It receives its core funding, $92 million, from the Bill and Melinda Gates Foundation and the Open Philanthropy Project. The Target Malaria project aims to create a GDO to target the Anopheles gambiae species of Malaria-carrying mosquito by reducing the number of female mosquitoes as it is female mosquitoes that bite and transmit malaria. The gene drive modifies the mosquito's fertility gene: essential genes are cut, causing the females to create only male offspring or not to have any offspring at all. These initial modified mosquitoes will then pass on their genes to a high percentage of their offspring, spreading auto-extinction genes throughout the population.

Target Malaria is adopting a phased approach and will not release the gene drive mosquitoes right away. The first step has been to lobby the government to allow the release of 10,000 sterile GM (but non-GDO) mosquitoes in two villages in Burkina Faso. It is not expected that these initial GM mosquitos will reduce malaria. However, by obtaining government approval they demonstrate that regulatory controls can be weakened such that Target Malaria will be able to release GDOs as soon as they want to do so. GM mosquitoes are currently being kept in a contained insectary at the government funded research institute, the Institut de Recherche en Sciences de la Santé (IRSS). Target Malaria also has insectaries in Mali at the University of Bamako Malaria Research and Training Center (MRTC) and in Uganda at the Uganda Virus Research (UVRI) Institute in Entebbe. The project is also said to be active in Kenya and Ghana.

Investigations carried out in October 2018 revealed that the communities in Bana and Sourkoudingan in Burkina Faso where the first Target Malaria mosquitoes will be released were not properly consulted or informed about the project. Most journalists that visited the test areas did so accompanied by Target Malaria, and the communities in the villages have not had access to information about either the GM mosquitos or GDOs independently of Target Malaria. They were therefore not able to make a decision that was based on hearing a balance of opinions. Civil society groups are also concerned that there has been no published risk assessment undertaken in Target Malaria's experiment in Burkina Faso and no one really knows what the consequences will be. Scientists have developed mathematical models[7] which suggest that when it comes to gene drive experiments in the real world, outcomes could be very risky, with altered genes potentially spreading to places where a species is not invasive, but a well-established part of the ecosystem.

[6] GeneWatch UK, "Oxitec's GM Insects: Failed in the Field?" Briefing Paper, May 2018, http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/Failed_in_the_field_fin.pdf

[7] Charleston Noble et al, "Current CRISPR gene drive systems are likely to be highly invasive in wild populations," bioRxiv, 2018, https://www.biorxiv.org/content/10.1101/219022v1

A decrease in one species could lead to an increase in another or, alternatively, a gene drive could spread between species causing potentially devastating effects. Civil society groups have denounced Target Malaria for using Burkinabe people like guinea pigs for their experiments. They have called for a moratorium on both GM insects and GDOs and for the risks of the technology to be properly evaluated.

> *"It's not just the targeted village which is important, it's the whole region, even the whole country... They cannot confine the mosquitoes to remain in the village. When people come to test them out such projects, generally there's a lot of funding involved. We would like more information about the project...as it's the first experiment of its kind and it's starting here with us, it's worrying. To be the guinea pigs of this kind of experiment is worrying."*
>
> *– Douda Kambe Ouattara, Y'en A Marre, Burkina Faso*

Military and Philanthro-Capitalist Investments on Gene Drives

Apart from the US defense industry, the other biggest funder of GDO development is the Bill and Melinda Gates Foundation, the largest philanthropic organization in the world, which has invested substantial sums of money in health and agriculture initiatives, particularly in Africa. The Foundation is known for its enthusiasm for genetic engineering fixes (for example it previously held 500,000 US dollars worth of shares in Monsanto – now Bayer-Monsanto). The Gates Foundation's largest contribution to GDO development goes to the Target Malaria project which intends to experiment with gene drives on Africa (see above).

GDO funders are mostly concentrated in the US, with significant funders in addition to those listed above including the Open Philanthropy Project (founded by Facebook co-founder Dustin Moskovitz), the Foundation for the National Institutes of Health (FNIH) and foundations established by the Microsoft co-founder Paul Allen. The Tata Trusts originate in India, but nonetheless spend their GDO funds on research based in the US.

Funder	Recipient	Value (US $)
DARPA	Various projects including 'Safe Genes'	65 - 100 million
Gates Foundation	Target Malaria	75 million
Tata Trusts	Center for Active Genetics	70 million
Open Philantrophy Project	Target Malaria	17.5 million
Gates Foundation	Foundation for the National Institutes of Health	9.43 million
Gates Foundation	Massachusetts General Hospital Corporation	2.587 million
Open Philantrophy Project	NEPAD/African Union	2.35 million
Gates Foundation	Emerging Ag Inc	1.6 million
Paul G Allen Frontiers Group	Center for Active Genetics	1.5 million
California Cherry Board	UC Riverside	500,000 (approx)
MaxMind	MIT and George Washington Universtity (for Schistosomiasis)	100,000

Gene Drive Organisms: Dangers and Impacts

Threats to biodiversity: GDOs are designed to spread and intentionally impact entire ecosystems. They are likely to become invasive in wild populations and could create mutations. Eradicating one species might unpredictably open space for the expansion of another species, which may carry diseases, affect pollination, or otherwise threaten biodiversity. Forced extinction is incompatible with conservation.

Threats to food security: A GDO that enters a farmer's production and spreads (intentionally or otherwise) could affect harvests, pollinators, predation, on-farm biodiversity, or could even be intentionally designed to suppress food production. Gene drives could foreseeably be used to strengthen monopolies by agribusiness interests with negative effects on small farmers and peasants.

False solutions – techno-fixing conservation and health: GDOs are part of a wider move toward finding simplistic technological solutions to problems that have deeper systemic causes, while leaving the larger power systems unchanged. Gene drive technologies do not spring from traditional knowledge systems of ecological management but from knowledge systems (such as synthetic biology) backed by monopoly protections and rooted in a colonialist mind-frame. These technologies are experimental and expensive at a time when we know that we should focus on the root causes of the problems we face instead of being distracted by speculative technofixes.

Using gene drives as weapons: Gene drives, as evidenced by DARPA funding and interest from the US military's secret JASON Group, as well as the International Bioweapons convention, are already being envisioned for military use. Potential biowarfare uses of gene drives range from attacking food sources to weaponizing flying insects.

Human Rights – Indigenous and sovereign territories: GDOs are designed to spread in nature and do not respect territorial boundaries. The release of a GDO could spread into and impact indigenous territories and therefore requires the free, prior and informed consent of all peoples whose territories may be affected. The rights, not only of living indigenous peoples, but that of future generations, would be infringed by any GDO release. Once released, this violation can not be undone.

Ethics: GDOs may reshape ecosystems, and their developers are claiming they have the authority to redirect evolutionary development. If the removal or alteration of a species by a GDO were to have significant negative ecological or other impacts after several generations, there may be no means for those who experience loss to claim damages and those responsible may lay beyond liability. A far more basic ethical question is whether humans, particularly corporations and governments, have the right to deliberately intervene in evolutionary processes. Promoting population extermination tools at a time when the world is undergoing the sixth great extinction seems like adding fuel to the fire of species loss rather than reversing it. Many cultures and worldviews, especially among traditional and indigenous societies, have strong objections to engineering the living world and regard protecting ecological balances as being among humanity's sacred duties.

Potential controls on GDOs

1. International Governance

UN Convention on Biological Diversity

In the last five years, the topic of gene drive governance has moved rapidly to the center of international biodiversity negotiations. At the international level, oversight on gene drives is coming into being at the United Nations Convention for Biological Diversity (CBD) which is an international legally-binding treaty with three main goals: conservation of biodiversity, sustainable use of biodiversity, and fair and equitable sharing of the benefits arising from the use of genetic resources.

In November 2018, at the thirteenth meeting of the CBD in Sharm-el-Sheikh, some countries, food sovereignty activists, indigenous people, and African civil society groups pushed for a moratorium on GDOs. Over 250 leading individuals and organizations from the global food movement backed this call. However, the call for a moratorium was surprisingly blocked by the Africa Group, a regional negotiating bloc representing African countries, which instead adopted a 'consensus' on GDOs for malaria elimination, based on the position of the African Union. The influence of the biotechnology industry and gene drive proponents at the CBD cannot be discounted: employees from Target Malaria were present on the negotiating teams of at least two African countries. At the end of the 2018 negotiating process of the CBD, 196 countries agreed on stringent rules on the use of GDOs. The UN's final agreement recognized the "uncertainties" inherent in the use of gene drives and called upon governments to exercise great caution in releasing gene drive-modified organisms for experimental research.

According to the agreement, gene drive experiments should be carried out only when "scientifically sound case-by-case risk assessments have been carried out," and "risk management measures are in place to avoid or minimize potential adverse effects." Organizations seeking to release gene drive organisms should also obtain the "free, prior, and informed consent" (FPIC) of potentially affected communities. The CBD will develop guidance on how to assess the risks of gene drives. In this context, it would at the least be wrong for countries to move ahead with potential gene drive releases ahead of that guidance.

2. Regional Governance

The Open Philanthropy Project (established by a co-founder of Facebook) awarded the economic development program of the African Union (AU), the New Partnership for Africa's Development (NEPAD) 2,350,000 US dollars to "support the evaluation, preparation, and potential deployment of gene drive technologies in some African regions" in 2017, "with the goal of supporting gene drive technologies to help eliminate malaria in Sub-Saharan Africa if feasible, ethical, safe, approved by the regulatory authorities, and supported by the affected communities." This funding was awarded less than a year before an AU/NEPAD report supporting the potential deployment of gene drive mosquitoes across the African Union member states was published.

In July 2018, the AU released its report endorsing the development of gene drive technology as well as "enabling legislation" for their deployment across its member states. The report makes a number of claims about gene drives which have been criticized as unsubstantiated. For instance, even though the field of gene drive research is still in its infancy and gene drive technology cannot be recalled once it has been deployed, the AU claims that gene drives present a realistic option for effective disease control and that "potential benefits for African countries will almost certainly be extensive."

The report endorses the passing of enabling legislation for gene drive development and eventual deployment. It also claims that "no major risk factors are foreseen that cannot be mitigated, and the potential benefits associated with malaria elimination will almost certainly outweigh any minor risks observed." However, critical questions remain about potential negative effects; the anopheles gambiae mosquito could develop a mutation, preventing the gene drive from working, or it could be so aggressive as to invade an entire territory.[8]

THE RIGHT TO KNOW AND THE RIGHT TO SAY NO

Free, Prior and Informed Consent (FPIC) is a specific right that applies to indigenous peoples and local communities and is recognized in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). It allows them to give or withhold consent to a project that may affect them or their territories. Once they have given their consent, they can withdraw it at any stage. Furthermore, FPIC enables them to negotiate the conditions under which the project will be designed, implemented, monitored and evaluated. This is also embedded within the universal right to self-determination.

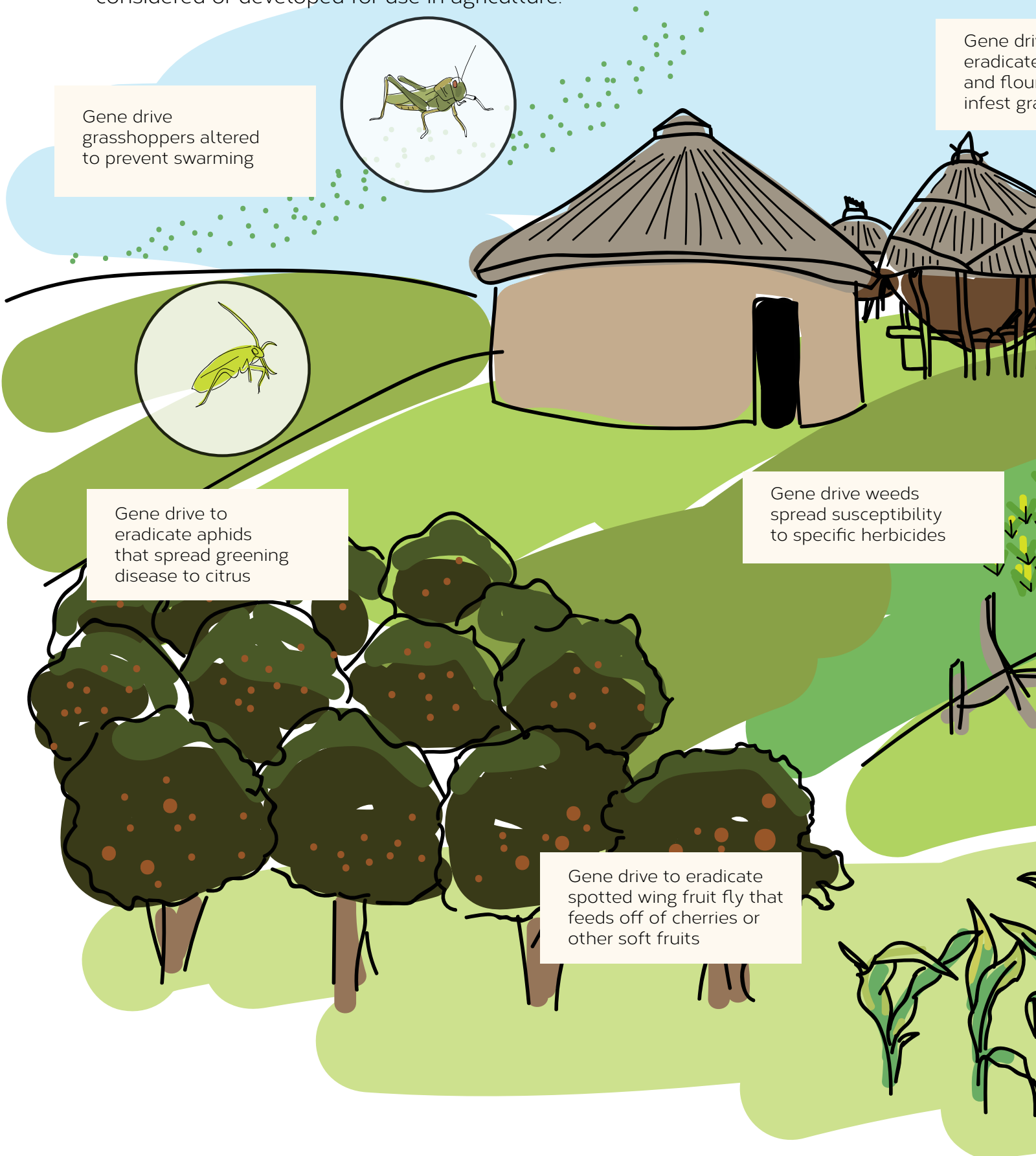
FPIC is a potentially powerful tool for communities but has been ignored or manipulated far too often. For example, proponents of projects often conflate consultation with consent, claiming that because they met with some members of a community, they have consent. It is also often the case that projects will hand-pick or manipulate certain members of the community into giving consent, but not include everyone in a free and fully informed process. Sadly, this common pattern appears to be repeating itself with GDOs in Africa.

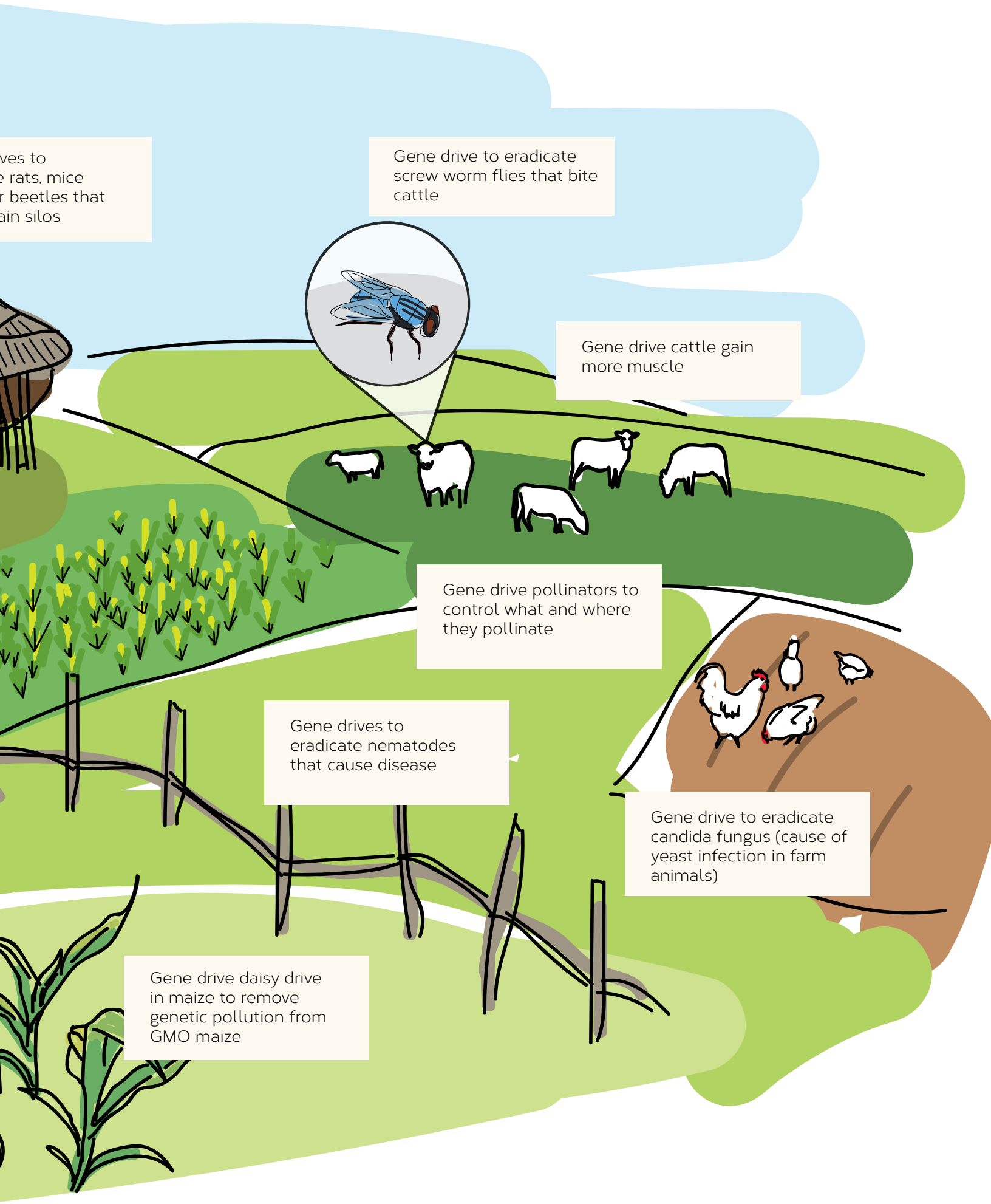
> *"If I am not able to understand, I cannot give my consent, because I do not know what damage will be caused by these (genetically modified) mosquitoes. In any case, it makes me afraid because I don't know what is going to happen."*
>
> *– Farmer, Bana Village, Burkina Faso*

[8] Carl Zimmer, "'Gene Drives' Are Too Risky for Field Trials, Scientists Say," The New York Times, 16 November 2017, https://www.nytimes.com/2017/11/16/science/gene-drives-crispr.html

The Gene Driven Farm

This graphic illustrates some of the areas in which gene drives are being considered or developed for use in agriculture.




ves to
e rats, mice
r beetles that
ain silos
Gene drive to eradicate screw worm flies that bite cattle
Gene drive cattle gain more muscle
Gene drive pollinators to control what and where they pollinate
Gene drives to eradicate nematodes that cause disease
Gene drive to eradicate candida fungus (cause of yeast infection in farm animals)
Gene drive daisy drive in maize to remove genetic pollution from GMO maize

GDOs in the context of the Sustainable Development Goals

As well as the potential risks of the technology itself, GDOs are being developed as part of what has been called a fourth industrial revolution involving 'precision' farming and 'digital agriculture.' GDOs are thus tied into models of agriculture that not only directly threaten African ecosystems, but form part of a hi-tech package including the use of New GM seeds, drones and chemicals that undermine agroecological approaches to farming and food sovereignty. Even if it proves impossible to develop GDOs that deliver any of the promised benefits, investments in them divert much needed resources and the attention of policymakers from existing and effective technologies for sustainable farming. As such, the development of GDOs would be likely to work against the implementation of the UN Sustainable Development Goals, which all African countries have endorsed.

What can civil society do?

Although the CBD has provided the basis for stringent rules on the release of gene drives, gene drive experiments are still going ahead, and Target Malaria has not abandoned the plan to release 10,000 genetically modified mosquitoes in Burkina Faso as a step towards gene drive release. There is plenty that can still be done.

Call for the use of alternative and existing prevention and treatment methods for malaria: A global program of malaria control led to deaths from malaria falling by half between the years 2000 and 2015. The disease was completely eradicated in Sri Lanka in 2016 and in Paraguay in 2018. Argentina and Algeria were also certified as malaria free by the WHO in 2019. These victories were said to be based on a combination of long-lasting insecticide-treated bed nets (LLINs); indoor residual spraying (IRS) of insecticides in homes at risk for malaria; preventative treatments for children and pregnant women; and access to diagnosis and treatment for malaria infections. In the case of Argentina and Algeria, the WHO states that eradication of the disease was a result of improved efforts to detect cases of the disease, as well as free diagnosis and treatment. In Zanzibar, the malaria transmission rate dropped by 94 percent as a result of a nationwide control programme and access to tools for prevention, diagnosis and treatment, including free mosquito nets.[9] Within Burkina Faso, civil society groups have called for the use of indigenous plants in the treatment of malaria. With a combination of indigenous methods of treatment, a strengthening of public health care systems, and putting in place affordable, widespread prevention and treatment methods, it is possible to eliminate malaria without the deployment of risky technologies like gene drives.

[9] Mohamed Issa, "Zanzibar anti-malaria drive cuts new cases by 94pc," The East African, 28 February 2019, https://www.theeastafrican.co.ke/scienceandhealth/Zanzibar-anti-malaria-drive-cuts-new-cases-by-94-per-cent-/3073694-5003300-tfjsxo/index.html

COMPLEMENTARY APPROACHES TO MALARIA ERADICATION[10]

Public health specialists are drawing attention to new and existing techniques that could supplement existing techniques, such as:

- Attractive toxic sugar baits (ATSBs): These take advantage of mosquito sugar feeding to administer an oral toxin and are capable of locally reducing malaria vector populations;
- Swarm sprays: Many vector mosquitoes form swarms when mating which can be sprayed with insecticide by local volunteers, giving reductions in vector density and mating success;
- Housing improvements: Modern housing and modifications to existing homes can provide protection against malaria transmission;
- Treatment of livestock: Many mosquitoes also target livestock, so treatment of livestock or the structures housing them with insecticides can reduce mosquito numbers
- Spatial repellents: These are airborne chemicals that cause changes in insect behaviour and which show potential for reducing transmission
- Improved storm drains and removal/cleaning of sources of stagnant water, including roof gutters, old tires, plastics, etc
- Proper disposal of all waste material
- Creation of stock ponds with mosquito-eating fish
- Some researchers are considering the role of traditional medicines and healers which are already used in many communities affected by malaria. Some researchers have proposed giving them a greater role in public health programmes

Publicize information on gene drives: Within Burkina Faso, journalists have been instrumental in publicizing information on Target Malaria's project and on opposition from civil society in the media. Such publicly available information can provoke discussions and can help to highlight the concerns of local communities on radio, on television or in newspapers. Conversely, civil society groups can also communicate much needed information and developments to farmers, rural communities and people who might not have access to independent information.

Scientists, ethicists, environmental groups, civil society groups, faith groups, politicians, young people, lawyers and even artists and poets can also speak out clearly against gene drives in a concerted and public way, calling for the withdrawal of support for the funding and continued promotion of gene drive technology.

Monitor gene drive developments and legislation at the national level: As Target Malaria continues its projects in Burkina Faso, Mali, Uganda and possibly Kenya, civil society can begin monitoring developments on gene drives and other new technologies in their respective countries, including acquiring an awareness of national level legislation and biosafety regulations. In many places, negotiations are occurring at high levels and beneath the radar of those civil society groups who might hold them accountable. Journalists and activists can play a key role in pressuring their governments to release information on GDOs to the public and engage potentially impacted communities in a truly democratic and participatory process.

[10] Critical Scientists Switzerland, European Network of Scientists for Social and Environmental Responsibility, Vereinigung Deutscher Wissenschaftler, "Gene Drives: A report on their science, applications, social aspects, ethics and regulations," 2019, https://genedrives.ch/report/

Continue to demand a moratorium: In 2016, 170 international civil society organizations called for a moratorium on gene drive releases, including applied research such as open field trial releases, until further understanding of the potential risks are understood. In 2018, over 250 groups and high profile individuals from the global food movement reiterated this call by asking for gene drives to be kept out of food and agriculture. Given serious governance gaps, concerns regarding the inability to regulate transboundary movement of GDOs, inability to contain gene drives following field trials and commercial releases, unknown ecological and other impacts, and the serious lack of the free, prior and informed consent of indigenous people and local communities, civil society groups can continue to demand an immediate halt to gene drive releases and experimentation from countries that are party to the African Union and from their own national governments.

Challenge the AU position on gene drives: The AU position on gene drives fails to consider key concerns and gaps and is only developed in the context of one specific use (malarial mosquitos) not a wider consideration of the technology. Civil society can apply pressure on their respective governments to consider these failings in the AU position and to take an alternative position on gene drives. The outcome of the CBD, with its focus on the need for proper risk assessment and FPIC, can help to provide leverage to such demands.

> *"It is out of the question for us to let these scientists continue to conduct dangerous experiments outside their laboratory outside any control over the unknown consequences for humans, for animals and for the environment. We simply want them to stop the research into GM mosquitoes here in our country."*
>
> *–Ali Tapsoba, Terre à Vie, Burkina Faso*

Notes


etc
GROUP
monitoring power
tracking technology
strengthening diversity

HOMEF
HEALTH OF MOTHER EARTH foundation

PAGEN

AFSA
ALLIANCE FOR FOOD SOVEREIGNTY IN AFRICA

TERRE À VIE