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African green hydrogen: Using sustainable fertilisers for industrial and agricultural development in Morocco, Egypt and Kenya

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African countries have long sought economic transformation through industrialisation and agricultural development. Integrating 'green' objectives – such as transitioning to low-carbon economies – into these ambitions introduces new challenges and complexities but can also unlock new opportunities.

This paper explores how combining green hydrogen and fertiliser production can be a catalyst for African green industrialisation and agricultural development, highlighting how one sector can kick-start the other. Our analysis of hydrogen plans and early investments in Morocco, Egypt and Kenya shows that renewable energy potential is only part of the equation for successfully establishing green hydrogen and fertiliser production in Africa. Morocco's solar potential and proximity to the EU, Egypt's high domestic demand and the Suez Canal, and Kenya's renewable energy resources, all highlight diverse pathways for establishing a green hydrogen economy. However, each pathway comes with its own complexities, emphasising the importance of considering the interplay between industrialisation, agriculture and political economy factors in shaping the future of green hydrogen and fertilisers in Africa.

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Acronyms

DFIs	Development Finance Institutions
EBRD	European Bank for Reconstruction and Development
EU	European Union
H2	Hydrogen
KfW	German Development Bank (*Kreditanstalt für Wiederaufbau*)
NH3	Ammonia
NOx	Nitrous oxides

Key terms explained

Hydrogen (H_2): Clean-burning gas that can be used as a fuel, an energy carrier, or a feedstock. Mass transport needs either high pressure for density or very low temperatures for liquid form. There are different 'colours' of hydrogen depending on their production:

- **Black hydrogen**: Hydrogen produced with coal without carbon capture;
- **Brown/grey hydrogen**: Hydrogen produced with natural gas. It is the main hydrogen currently produced;
- **Blue hydrogen**: Hydrogen produced through fossil fuels but with capture and storage of carbon emitted; and
- **Green hydrogen**: Hydrogen produced from renewable energy sources, such as solar or wind power, using electrolysis.

Ammonia (NH_3): A toxic gas which can be produced by synthesising nitrogen and hydrogen in the Haber-Bosch process. Ammonia is a crucial ingredient in nitrogen fertilisers.
Green ammonia: Ammonia produced using green hydrogen and nitrogen as a feedstock in a sustainably-powered Haber-Bosch process.
Haber-Bosch process: High energy-intensive method for synthesising ammonia from nitrogen and hydrogen through high pressure and heat.
Fertilisers: Used to enhance soil fertility and promote plant growth. Nitrogen-heavy fertilisers can be derived from organic or inorganic sources.
Green or low-carbon fertiliser: Nitrogen fertilisers derived from green ammonia.
Electrolysis: Process that uses electricity to break down chemical compounds into their constituent elements. Used to produce hydrogen from water.
Feedstock: Raw material used as an input. For example, nitrogen and hydrogen are feedstocks for ammonia production.

1. Introduction: African hydrogen economies and fertiliser production

African countries have long pursued economic transformation through industrialisation and agricultural development. 'Greening' ambitions, or the need to transition to low-carbon societies, can add complexity to these objectives, but it also provides new windows of opportunity (Lema et al 2020; Medinilla and Byiers 2023). Green hydrogen can provide such an opportunity by leveraging the massive renewable energy potential of African countries.

Green hydrogen is the only viable decarbonisation option for industries with high heating requirements, like steel production, or those using ammonia as feedstock like nitrogen fertilisers. Countries and regions aiming to rely on green hydrogen for industry decarbonisation, especially those with net-zero targets and carbon pricing like the European Union (EU), are investing heavily in this sector. At least 45 countries today have national hydrogen strategies, and over 100 large-scale projects are planned globally, including in several African countries (IEA 2024a).

African nations like Egypt, Kenya, South Africa, and Morocco are rolling out green hydrogen strategies to decarbonise their industrial base, mitigate natural gas price volatility, and harness renewable energy for new industries such as e-fuels, and future demand for derivatives like ammonia for shipping. More importantly, exporting hydrogen and its derivatives, particularly to the EU, is often viewed as crucial for achieving the necessary scale of hydrogen production facilities.

The hydrogen economy could reshape global energy geographies, with the best production sites located in low- and middle-income countries rich in solar and wind energy potential. The costs of shipping hydrogen far exceed those of fossil fuels, making hydrogen consumption more sensitive to location. Simply put, if shipping hydrogen is expensive, it may make more sense to produce and export hydrogen-based industrial products from African countries, rather than relying on exports of the molecules themselves.

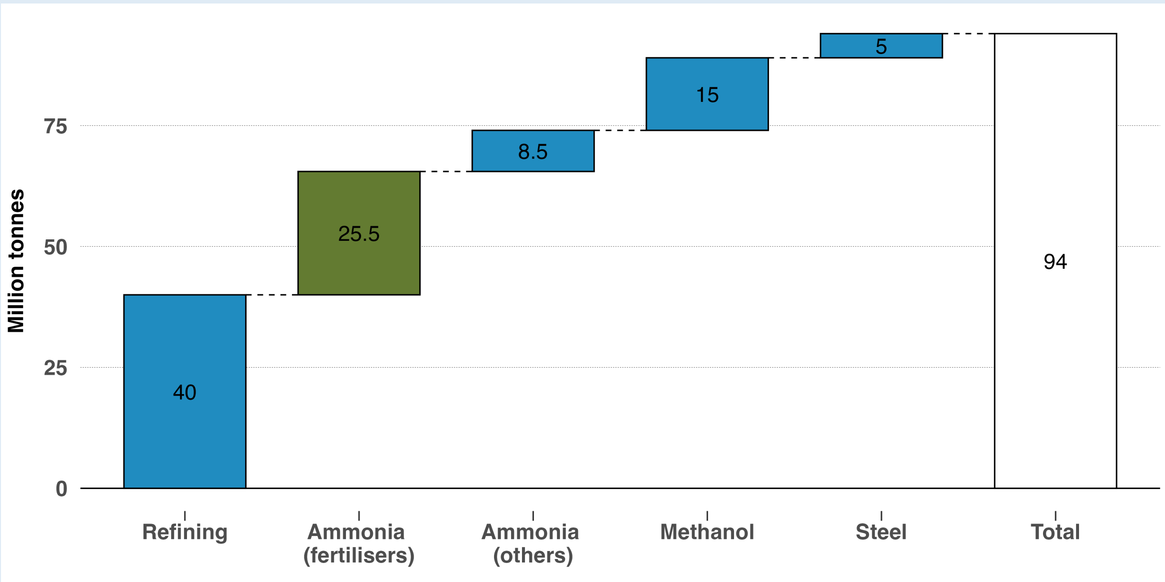
This could further strengthen the case for investing in decarbonised energy-intensive industries in African countries, close to where green hydrogen can be produced at the cheapest possible rate. At the same time, the EU is likely to stay a lead market for early green hydrogen consumption, due to subsidies, and comparatively highly ambitious industry decarbonisation targets and policies. African countries wanting to create a strong local green hydrogen consumption market face the challenge of balancing hydrogen exports to Europe with fostering domestic industrialisation.

Box 1: (Green) Hydrogen today

Currently, hydrogen is predominantly used for oil refining, producing ammonia for fertilisers, and methanol (Figure 1), but it presents new opportunities amid the global shift from fossil fuels. Hydrogen and derivatives like ammonia can serve as feedstock for low-carbon industries, replace fossil fuels in shipping and aviation, and act as an energy carrier. While it is vital for hard-to-abate sectors, current production of hydrogen from natural gas and coal is highly carbon-intensive.

Green hydrogen, produced using renewable energy, has a significantly lower carbon footprint than grey hydrogen, which is derived from fossil fuels. Despite its environmental benefits, green hydrogen faces challenges such as immature technology, high costs, storage difficulties, and the need for cheap, mass-produced low-carbon electricity (Schelling 2023). The average production cost of green hydrogen from electrolysis was $6.4 per kg, triple the price of grey hydrogen from natural gas (Schelling 2023).

Figure 1: Hydrogen production and use in 2021



Source: authors based on IEA 2022a

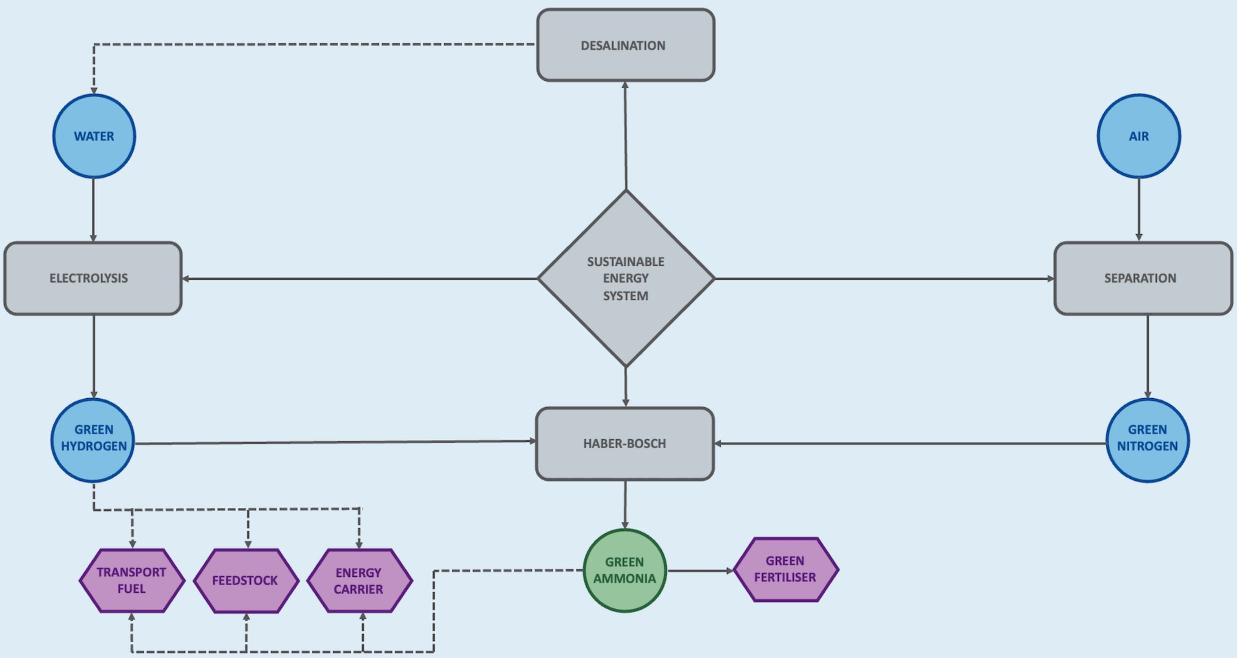
Box 2: Green fertiliser production

Hydrogen is a crucial element in producing nitrogen fertiliser. By combining hydrogen with nitrogen through the energy-intensive Haber-Bosch process, using high pressure and heat,[1] the resulting ammonia gas contains about 82% nitrogen and can be further processed into fertiliser end-use products, like the widely used urea.

Ammonia production emits high levels of greenhouse gases, accounting for about 1.4% of global greenhouse gas emissions (The Royal Society 2020; Kyriakou et al. 2020).
After application, fertilisers also release nitrous oxides (NOx) and methane (CH4), which are potent greenhouse gases. NOx, in particular, contributes to ozone depletion and is an important source of particle pollution.

Green or low-carbon fertiliser uses a similar Haber-Bosh process to produce nitrogen-rich ammonia, but with key differences: (a) they replace fossil-fuel derived hydrogen with hydrogen separated from water via electrolysis, and (b) they use renewable energy across the production chain. In doing so it cuts out the emissions linked to both hydrogen and ammonia production. However, the nitrous oxides, and methane emissions resulting from fertiliser application remain, meaning that achieving net-zero emissions from fertiliser would require carbon offset measures (Tonelli et al. 2024).

Figure 2: Green fertiliser production chain



Source: authors adapted from The Royal Society 2020

[1] Previously, the hydrogen used in the Haber-Bosch process was typically obtained from water hydrolysis, but now steam methane reforming is more efficient and cheaper, yet still energy-intensive and using a potent greenhouse gas.

Linking industrialisation and agricultural development

Producing fertiliser with green hydrogen is considered one of the most promising ways for establishing a green hydrogen sector in Africa. Ammonia, essential for synthetic fertiliser, is widely used in agricultural production. Increased fertiliser use is crucial for revitalising Africa's underperforming agricultural sector, which is a vital step in broader economic transformation efforts. This approach links agricultural and industrial development and allows Africa to benefit from the global shift toward a greener economy.

Green hydrogen for fertilisers could offer multiple opportunities for African economies. In theory, large-scale green fertiliser production would allow African countries to leverage their vast renewable energy potential to lower their import dependence for nitrogen fertiliser or its feedstock. More African production could create much-needed industrial jobs. Domestic green ammonia production for fertilisers could hedge against global market volatility and price shocks in fertiliser markets - as the one triggered by the Russian invasion of Ukraine in 2022 - while enabling African countries to export to carbon-regulated markets like the EU, which is set to implement the Carbon Border Adjustment Mechanism on certain goods, including fertiliser. While many new use-cases of hydrogen derivatives are still taking shape, worldwide demand for nitrogen fertilisers is projected to grow continuously in the near future (Schmitt et al. 2022).

Assessing the potential of African green hydrogen and fertiliser production

In practice, numerous domestic and international factors will determine whether African green fertiliser production will be viable in the short-to medium-term. Some of these are technological: hydrogen economies worldwide are very much in their infancy, and even the most ambitious carbon compliance markets, like the EU, still largely rely on fossil fuels for their industries. Others are related to global markets: scenarios for green hydrogen and ammonia offtake, along with prices, are based on early-stage policy targets, which can still change - notably those of the EU (Medinilla and Dekeyser 2024). Others yet may be linked to domestic and sectoral dynamics, such as agricultural input subsidies or vested interests in fertiliser production and distribution.

Producing green fertiliser is a complex process requiring multiple, often large-scale, industrial facilities (Box 2). Green fertiliser needs green ammonia, which requires green hydrogen, which might involve optional desalination plants in water-scarce regions. Ammonia, hydrogen and desalination facilities (and to a lesser degree nitrogen facilities) are all very energy intensive and need extensive - likely dedicated - renewable energy facilities. Large upfront capital investments are thus needed before fertiliser production can begin.

This paper explores the potential of green hydrogen and fertiliser production as catalysts for green industrialisation and agricultural development in Africa, examining how each sector can kick-start the other. Building on an initial analysis of green hydrogen and fertiliser dynamics published in the first half of 2024 (Medinilla and Dekeyser 2024), it zooms in on plans and early-stage investments in green hydrogen for nitrogen fertiliser production, and addresses the following questions:

1. *What opportunities and challenges exist for developing a green hydrogen sector in African countries, and how can the fertiliser sector contribute to this?*
2. *What policy interventions – both from an industrialisation (production) and agricultural development (use) perspective - can support the growth of a viable green fertiliser sector in African countries?*

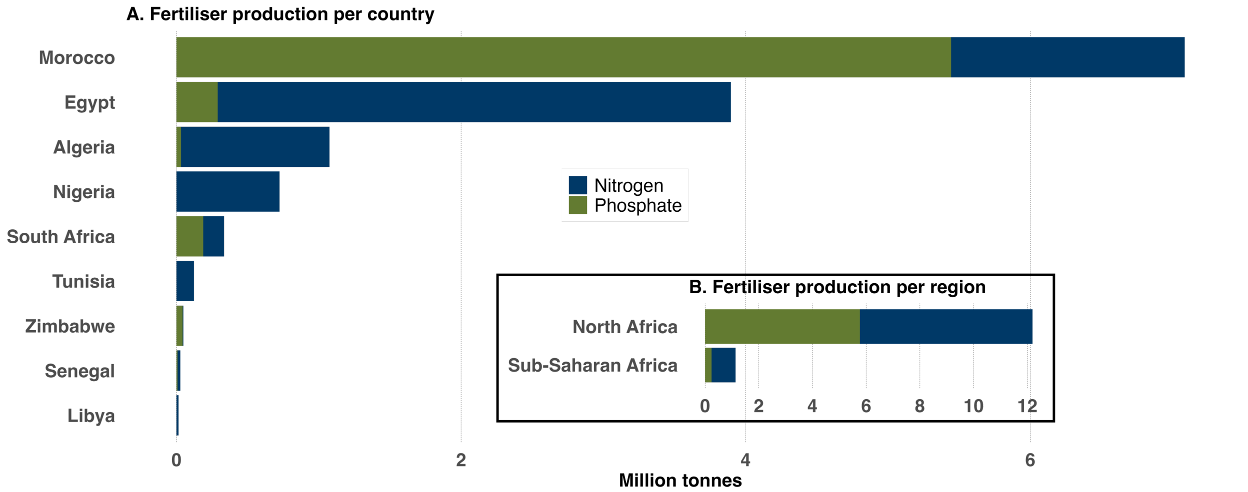
It concludes that green hydrogen production holds significant potential as a pillar for green industrialization and agricultural development in some African countries. By aligning green hydrogen projects with the fertiliser sector, certain African countries can reduce import dependency, boost agricultural productivity, and create new industrial jobs. However, success will depend on proactive policy interventions, such as investment-friendly frameworks, infrastructure development, and strategies for fostering local and regional demand for green fertiliser. Tackling financing and technological challenges will be essential for establishing a sustainable hydrogen economy that effectively integrates industrial and agricultural development.

2. African fertiliser markets: concentrated production and low consumption

Fertiliser use in Africa is among the lowest in the world on average. While this indicates considerable growth potential, it also highlights structural challenges for transitioning to green fertiliser production in the short-to medium-term. As discussed below, opportunities for the industrial production of green fertilisers are as much linked to energy as to agricultural factors.

African fertiliser production today is highly concentrated in North Africa. Egypt is by far the continent's largest nitrogen fertiliser producer, while Morocco, holding 70% of the world's confirmed phosphate reserves, is a global leader in phosphate fertiliser (Tanchum 2022a). There are no operating potash mines on the continent.

Figure 3: 2020 fertiliser production by type for (A) African countries and (B) by African regions



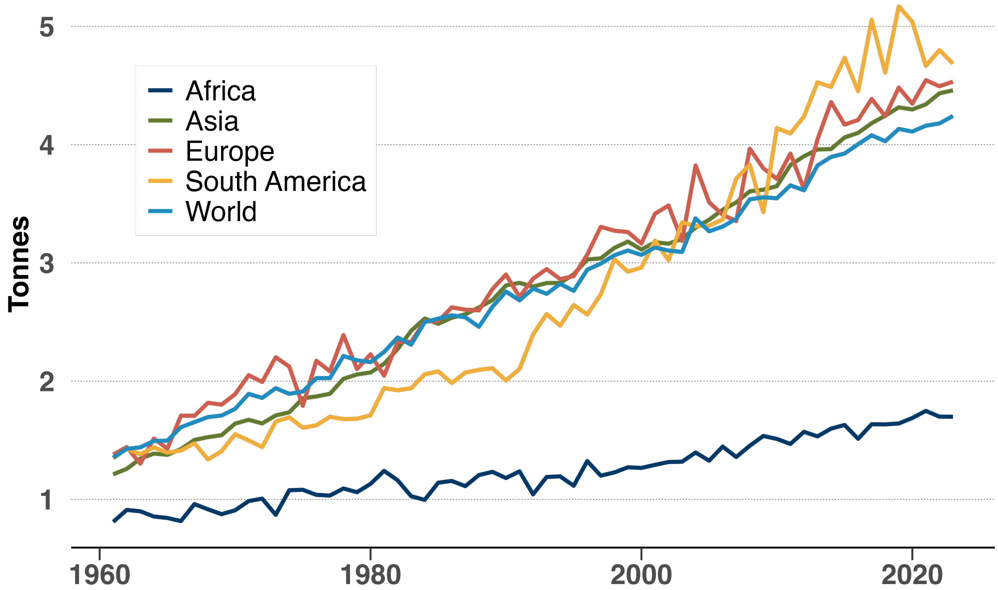
Source: authors based on FAOSTAT

Fertiliser use across Africa is also highly uneven. While North African farmers apply extensively, sub-Saharan African countries - with a few exceptions - neither produce nor consume significant amounts. Per capita fertiliser use in sub-Saharan Africa is less than half of North Africa's, seven times lower than the global average, and over ten times less than in Europe (Holden 2018).

Several factors contribute to low fertiliser use in Africa. Limited availability, especially of organic fertilisers, is one issue.[2] However, the primary obstacle is low demand due to high costs: fertilisers are often unaffordable for many farmers. High transport and transaction costs can account for half of the total fertiliser bill in some countries (Guèdègbé and Doukkali 2018). Furthermore, land constraints and poor crop profitability offer little incentive for farmers to further invest in farm management (Giller 2020). Some African countries, such as Nigeria, Malawi, and Zambia, heavily subsidised fertilisers through costly input subsidy schemes. While these subsidies can temporarily boost food production, the benefits are typically modest (Jayne et al. 2018).

[2] Commonly used sources, such as animal manure and crop residues, are in short supply because of low livestock density and their competing use as animal feed.

Figure 4: Continental cereal yields per hectare

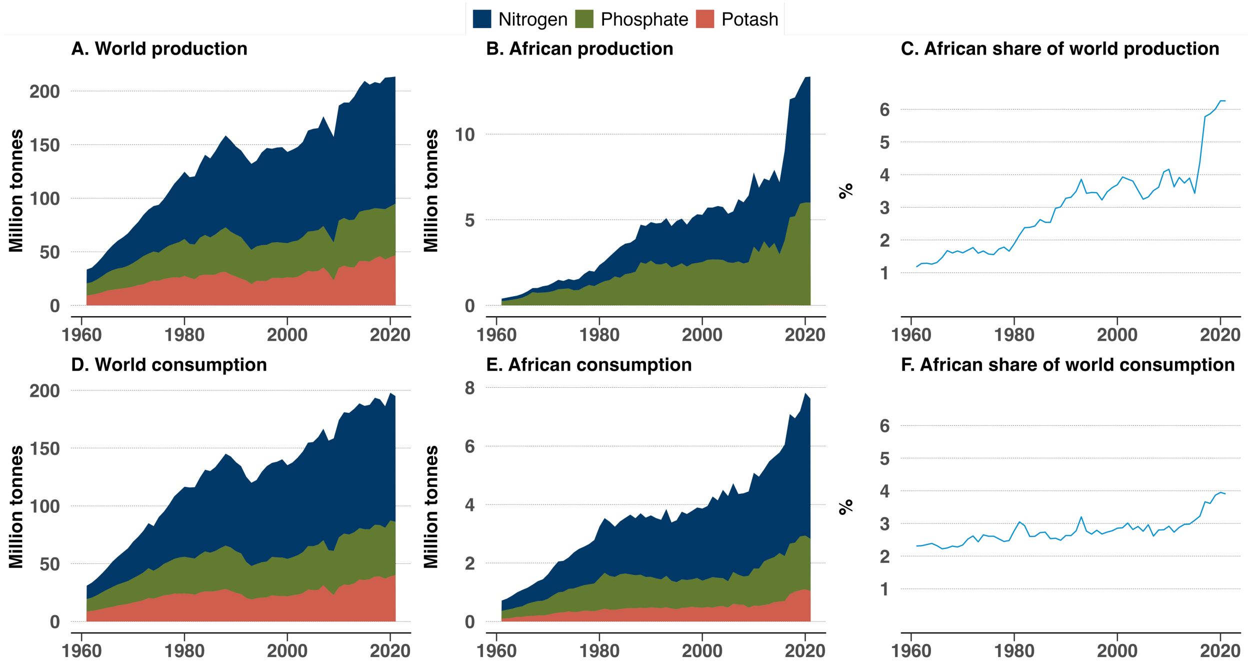


Source: authors based on FAOSTAT Data

Low fertiliser use in sub-Saharan Africa contributes to severe consequences, leading to low yields and land use change. Currently, sub-Saharan Africa produces about 80% of its total caloric needs, but a rising population and economic growth will sharply increase food demand, with cereal demand likely tripling by 2050. Without substantial agricultural intensification and expansion, African food security will increasingly depend on global markets (van Ittersum et al. 2016).

At the same time, agricultural land expansion is the leading cause of biodiversity loss in Africa, so closing the yield gap is critical for habitat preservation (Williams et al. 2020). On average, African crop yields remain far below the global average, contributing to poverty, food insecurity, low food self-sufficiency, reduced resilience, and increased carbon emissions. Increasing agricultural productivity across sub-Saharan Africa is therefore seen as one of the most important challenges of this century (Ritchie 2022).

Figure 5: Fertiliser production and consumption, 1960-2022



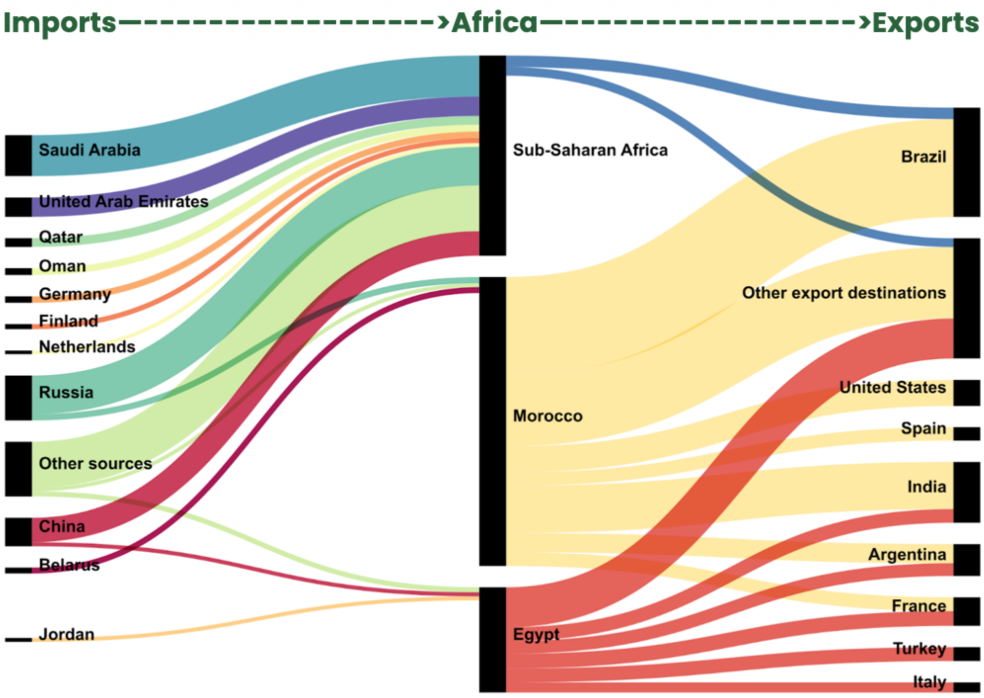
Source: authors based on FAOSTAT Data

Using more nitrogen fertiliser is an important piece of this complex puzzle, yet it also needs to be managed well to avoid negative environmental impacts. Alongside potash and phosphate, nitrogen is crucial to enhance crop yield (Zhang et al. 2015), yet almost all agricultural zones use either too little nitrogen, too much, or apply it in an inefficient manner. Too little nitrogen means low crop productivity, soil degradation and the 'mining' of nitrogen from the soil without replenishment; too much can lead to groundwater contamination, eutrophication, and nitrous oxide accumulation, in addition to the greenhouse gases emitted with current production methods. Inefficient application means that up to two-thirds of the applied nitrogen is not used by plants (Ritchie 2021). The challenge for Africa therefore is to leapfrog from a low yield, high nitrogen-efficiency system to a high yield, high nitrogen-efficiency one (Zhang et al. 2015).

Africa's fertiliser paradox

African fertiliser markets today highlight a difficult paradox: Africa is a net exporter of fertiliser, producing twice as much as it consumes, yet a large part of the continent depends on imports from the global market. North Africa accounts for more than 90% of all African fertiliser exports, while sub-Saharan Africa, on the other hand, imports up to 90% of its (limited) fertiliser demand. At face value, these numbers suggest a case for more intra-Africa trade in fertilisers, yet the types of nutrients differ. Thanks to Morocco's vast phosphate deposits, Africa exports mostly phosphate fertilisers while many African countries import nitrogen and potash fertilisers.

Figure 6: Net import and export of fertilisers into Africa, in US dollars, 2020



Source: authors based on UN COMTRADE 2024

Yet there is significant potential for more intra-African fertiliser trade. Despite substantial natural gas resources, which are needed for conventional nitrogen fertilisers, Africa imports most of its synthetic fertilisers (Shah and Odionye 2021). It is also reliant on imported feedstocks like ammonia.[3] Morocco is the largest importer of ammonia and hydrogen in Africa and ranks as the fourth-largest ammonia importer worldwide, primarily sourcing from Trinidad and Tobago and Russia (UN COMTRADE 2024).

The import dependence of most African countries makes them highly vulnerable to price shocks. The Russian invasion of Ukraine contributed to a sharp increase in global fertiliser prices, which remain significantly higher than pre-war levels.[4] Demand has also been heavily impacted, particularly in Africa, with a slower price decline in 2023 (Rice and Vos 2024). This reduced affordability threatens agricultural productivity and squeezes farmers' profits. In this environment, domestic fertiliser production becomes even more critical to government efforts aimed at diversification and self-sufficiency (Busari 2022).

Green fertilisers, therefore, could offer a strategic solution to Africa's agricultural and industrial challenges, enabling countries to reduce dependency on volatile international markets, enhance food security, and supporting the modernisation of African agriculture African leaders

[3] In 2020, African countries imported $434 million and exported $81.6 million of ammonia.

[4] An upward trend began in 2021, with urea prices leading the surge. Potash prices skyrocketed by 300% in 2022. As of March 2024, diammonium phosphate remains 50% more expensive compared to January 2021, urea is up 61%, and potash a staggering 91%.

have long pursued.[5] However, the success of green fertiliser production will depend not only on technical and environmental factors but also on navigating the complex political economy of energy, trade, and investment across the continent, as explored in the next section.

3. Hydrogen economy and fertilisers in Morocco, Egypt, and Kenya

This section looks at the potential of green hydrogen and fertiliser production as a catalyst for green industrialisation and agricultural development in Morocco, Egypt, and Kenya, and how one sector could kick-start the other. It builds on ECDPM's multilevel analytical framework to study the political economy of green industrialisation which identifies four proactive strategies for green industrialisation in African countries:

1. Decarbonising existing industries;
2. Producing inputs for global green industries;
3. Manufacturing green goods for African markets; and
4. Leveraging 'brown', meaning, i.e., fossil-fueled, capabilities to jumpstart green industries.

Moving into green fertiliser production has elements of all these strategies. North African countries can use green energy to 'decarbonise existing production'. Countries also need to balance producing hydrogen and ammonia for local industrial use, and for exports as an 'input for global green industries'. Given the potentially large African market, green fertilisers can boost the manufacturing of green goods for African (regional) markets if achieving cost parity with conventional imports. Lastly, Egypt could use its existing conventional fertiliser facilities to partly offtake from its nascent hydrogen sector.[6]

Morocco: the major exporter

Morocco is generally regarded as very well positioned to profit from the opportunities offered in the hydrogen economy, especially through exports and the fertiliser sector. In 2021, it introduced an ambitious hydrogen strategy and roadmap in three phases, starting with industrial consumption and exports (2020-2030), then use of green hydrogen in the electricity sector (2030-2040), all the way to industrial heat, transport and aviation (2050; MEM 2021). In 2024, Morocco also launched its external 'green hydrogen offer', an ambitious agenda dedicating up to one million hectares of public land to position the country as a green

[5] African leaders have long pursued agricultural modernisation for African food self-sufficiency, issuing a string of political declarations, but with limited success. In 2014, African heads of state committed to invest 10% of all public resources to accelerate lagging agricultural growth (AU 2014). In practice, however, agriculture expenditures have actually decreased from 2014 (ReSAKSS 2023). In 2023, 34 African countries signed the Dakar II Declaration, agreeing that it is time for Africa to feed itself and fully unlock its agricultural potential to help feed the world.

[6] Investments are needed in Haber-Bosch plants when more than around 15% of the hydrogen supply doesn't come from an integrated steam methane reformer anymore. In other words, replacing natural gas with hydrogen in existing facilities likely requires significant modifications to the process, especially beyond a 15% blending threshold (Humperdinck et al. 2023).

hydrogen hub, and attract early international hydrogen economy investments. In addition to land allocation, Morocco also offers a battery of incentives and project support measures to potential hydrogen investors (MASEN 2024).

Energy, geography and industrial capabilities

Morocco's main strategic advantages in producing green hydrogen are its excellent solar and wind potential, proximity to the EU enabling pipeline exports, and demand for ammonia in its domestic fertiliser industry. Simply put, green hydrogen can reduce its dependence on imported natural gas and ammonia, while its renewable potential and proximity to the EU makes it a potentially competitive producer for the European market.

Morocco's state-owned fertiliser company OCP controls 70% of the world's known phosphate reserves and supplies a third of global phosphate.[7] Over the past 20 years, OCP has transformed from mining phosphate rock into a world leading fertiliser producer and largest employer in Morocco, employing more than 20,000 people, and quadrupling its turnover from $2.5 billion to $9.4 billion between 2005 and 2021 (Saleh 2023). OCP is highly profitable and has been on a consistent path of scaling up production (Srahna 2024).

OCP produces mainly for exports, with its biggest buyers being India and Brazil (OEC 2023; figure 6). Fertilisers are one of the country's leading export products, including to other African countries.[8] OCP accounts for 61% of phosphate fertilisers sold in Africa (Shah and Odionye 2021). While Africa represents just a quarter of OCP exports, the company views Africa as a major market for growth and invests in fertiliser plants in Nigeria, Ghana and Ethiopia, among others (Tanchum 2022b).

To produce nitrogen, however, Morocco's fertiliser industry currently relies on imported natural gas and ammonia, leaving it vulnerable to price volatility like in 2022 following the Russian invasion of Ukraine (Martin 2023). Producing green hydrogen could help 'hedge' against external price shocks, as well as support further development of Morocco's fertiliser industry, including expanding green fertiliser exports to Europe, which are subject to the Carbon Border Adjustment Mechanism (Medinilla and Dekeyser 2024).

In addition to national plans to develop its green hydrogen, mentioned above, OCP launched in 2023 a $13 billion green investment plan in order to significantly scale up fertiliser production by 2027, while also achieving full carbon neutrality by 2040 (OCP 2022). It also announced in 2023 plans for a €7 billion investment in green ammonia production, aiming to start production as early as 2026, and reach one million tons by 2027 (Eljechtimi 2023). Recently, it formed a 50-50% joint venture with Fortescue Future Industries to develop 'large-scale green ammonia and green fertiliser production' capacity for Morocco, Europe and international markets (Fortescue 2024).

[7] In the meantime, a large phosphate rock was found in Norway (The Economist 2023).

[8] For example, during the 2022 fertilisers price crisis, Morocco donated or discounted fertilisers to 20 African countries. Donations and subsequent OCP investments may have swayed Kenya to change its stance on the Western Sahara (Maina 2024; The Star 2022).

While many of these plans are still in the project development stage, OCP is able to mobilise finance for its plans. In May 2024, it completed a first $2 billion bond issue for its Green Investment Plan (OCP 2024a). The company also secured funding from European Development Finance Institutions (DFIs), such as the German Development Bank (KfW), to support its green energy development (OCP 2024b). Foreign investors are also gearing up in Morocco's hydrogen sector, with TotalEnergies announcing plans to invest €9.4 billion in the Guelmim-Oued Noun project for a solar-wind facility connected to an ammonia plant, and the Amun project, which is around €10 billion investment by CWP Global that could produce up to 5.6 million tonnes of green ammonia by 2027 (IEA 2024a). A pilot project in Guelmim is backed by the KfW for €300 million and is scheduled for commission in 2025 (KfW 2024). In October, Morocco announced the first land allocation under the 'hydrogen offer', selecting three European companies, including a joint venture with TotalEnergies to develop a 1 GW solar and wind power project to produce 200,000 tonnes per year of ammonia (Machado 2024).

Green hydrogen production in Morocco faces technical constraints. Projects are expected to rely on off-grid energy, as low-carbon sources are only a minor part of the country's current electricity mix. Morocco imports over 90% of its energy (EI 2024), so all announced hydrogen projects have dedicated power generation (Rikabi 2024). While this can help accelerate deployment, it can also lead to isolated industries or missed opportunities for investment in on-grid renewables. Additionally, the freshwater requirements for electrolysis will likely necessitate substantial investment in desalination.

A State-backed push to lead in hydrogen and fertilisers

Morocco's approach to green energy and industrialisation is a hybrid one, combining strengthening and modernising state-owned companies and creating the conditions for private investment in green technologies. Morocco began its ambitious renewable energy deployment plans in 2009 (SDPD and UN ESCWA 2018), hitting 4.6 GW of renewable energy capacity in 2024 (Ahmed and Cockayne 2024). Its energy reforms combine:

1. legislation with ambitious renewable energy targets and regulatory reforms to facilitate renewables deployment and investments;[9]
2. a public-private partnership financing model to combine and derisk public, private and multilateral finance for large-scale projects like the Noor Ouarzazate concentrated solar power plant;
3. dedicated institutions for managing and facilitating the energy transition like the Moroccan Agency for Sustainable Energy (MASEN); and
4. a network of institutions supporting innovation, research and development such as the Research Institute for Solar Energy and New Energies (IRESEN), alongside initiatives to build a skilled workforce for the green energy sector (IEA 2022b; Gazzon et al. 2024).

[9] For an overview: ESCWA 2018; Bounjou and El Mouadden Lalami 2023; Sinaceur 2023.

This combination of strong state backing, proactive investment promotion and the country's low investment profile has enabled Morocco to position itself relatively early and leverage its industrial capabilities to seek investment in green hydrogen and fertiliser production. As such, it is seen to be well positioned to be part of the first wave of green fertiliser production. Yet challenges remain. A primarily export-driven model risks developing an enclave economy, with weak links with the rest of the economy. Its ambitious approach to hydrogen development is not without its challenges and risks. Morocco's hydrogen offer identified no less than 2% of the country's land, while the desalination requirements for hydrogen may create additional risks for marine ecosystems.

Summary of political economy factors
Regional: Proximity to Europe makes it excellently placed as a green energy and hydrogen economy hub. Green fertiliser production could increase exports to the EU market under the Carbon Border Adjustment Mechanism (CBAM). **National**: Green energy reforms since 2009 and strong state-backed industrial decarbonisation and investment promotion have given Morocco a head start. As a state-owned enterprise, Morocco's fertiliser industry benefits from unique political backing and privileged access to resources, like 70% of the world's known phosphate rock reserves. **Sectoral**: Morocco's reliance on imported fossil fuels means that green hydrogen can hedge against price volatility. OCP's industrial capabilities and market position enable it to compete with other global fertiliser producers. OCP also has significant global market reach as well as access to international capital markets to finance its operations. **Overall**: Morocco not only has strong incentives to develop green fertilisers, but its highly profitable fertiliser industry and proactive green industrial policies make it well positioned to capitalise on projected global demand for green fertilisers.

Egypt: the aspiring hydrogen hub

Like Morocco, Egypt is positioning itself to become a regional leader in green hydrogen. The country is looking to leverage its Suez Canal Economic Zone to produce low carbon fuels, establish itself as a major bunkering hub for maritime fuels, and supply export and domestic markets for green ammonia. Egypt aims to capitalise on its strategic geographical position, existing natural gas production for blue hydrogen, and its domestic fertiliser industry which is a major off taker of ammonia.

Egypt's plans blend the four above mentioned strategies for green industrialisation in African countries: to decarbonise existing industries, produce inputs for global green industries (e.g., e-fuels), manufacture green goods for African markets (e.g., fertilisers), and leverage 'brown' capabilities to jumpstart green industries (e.g., blue hydrogen).

In August 2024, Egypt launched its National Strategy for Low-Carbon Hydrogen, developed with the support of the European Bank for Reconstruction and Development (EBRD 2024). The plan aims to create over 100,000 jobs and add $10-18 billion annually to Egypt's economy by 2040, focusing on both blue and green hydrogen. The strategy identifies fertiliser as the number one option for future demand, followed by marine fuels. A National Council for Green Hydrogen and its Derivatives oversees the implementation, with the goal to eventually capture 5-8% of the global hydrogen market by 2040 (SIS 2024; EBRD 2024).

Like most countries, Egypt's hydrogen strategy is a tool for investment promotion, targeting a mix of concessional finance from the EU and global green funds, as well as multilateral development banks and foreign investments. Several major project announcements were made recently, including $37 billion of ammonia project announcements at the June 2024 Egypt-EU Investment Conference (Atchison 2024).

Egypt has excellent solar potential and is one of the top locations globally to harvest wind energy (Moharram et al. 2022). Alongside this renewable energy potential, Egypt has decades-long experience with producing both grey and green hydrogen and ammonia. Between the 1960s and 2019, Egypt produced green hydrogen for ammonia using electricity from hydropower supplied by the Aswan Dam (EWI et al. 2023), before switching to grey ammonia production, partly due to cheap gas. It now produces grey hydrogen, which is several times cheaper than green, to supply its domestic market for ammonia.

Thanks to its gas reserves, Egypt has traditionally been self-sufficient in producing ammonia without relying on imported feedstock. However, recent declines in its gas output have necessitated imports, raising concerns about future energy security and price volatility (OEC 2024). Its plans, therefore, are initially driven by future green market opportunities and decarbonisation objectives, but could increasingly be also about import substitution considerations (figure 6).[10]

Fertiliser and bunkering fuel

Egypt is Africa's second biggest fertiliser producer, yet its fertiliser industry and market is fundamentally different from Morocco's. Egypt produces primarily nitrogen fertiliser for the domestic market, using grey hydrogen from natural gas, while Morocco has historically focused on phosphorus fertilisers for export. Egypt directly distributes subsidised fertilisers to farmers and uses a lower price for natural gas for local fertiliser factories (Kurdi et al. 2020). These subsidies lead to substantial overapplication with harmful environmental and financial effects: Egypt's fields receive an average of 330 kg of nitrogen fertiliser, compared to Kenya's 26 kg and Morocco's 23 kg. As a result, less than a third of its fertiliser is actually used by crops, with the rest wasted (Lassaletta et al. 2014). Rising gas prices have placed input subsidies under pressure and could lead to up to a 30% increase in fertiliser prices on the domestic market (Egypt Today 2024).

[10] Because of recent problems with the output from its gas fields, Egypt increasingly imports gas.

The Suez Canal provides Egypt with a unique opportunity to refuel ships. Annually, 22,000 ships transit the canal between Asia and Europe. Bunkering fuel, both ammonia and e-methanol, is therefore one of the main pillars of Egypt's hydrogen strategy, with multiple projects underway, centred around the Suez Canal Economic Zone, including a partnership with Maersk, for e-methanol production (Enterprise 2024). In 2023, Egypt refuelled the first green methanol container ship passing the Suez Canal (Takouleu 2023).

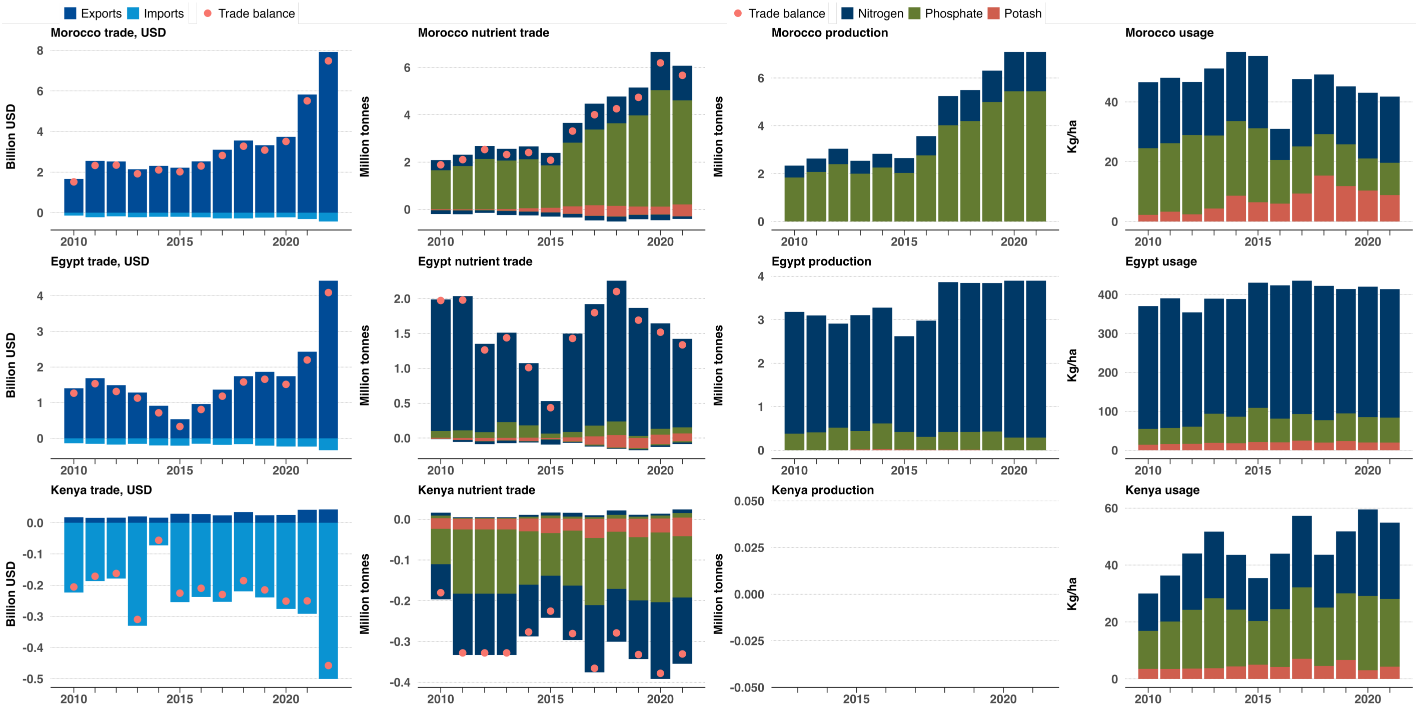
Bridging the demand gap

Overall, Egypt's hydrogen strategy is highly ambitious, driven by bold announcements and its strategic geography, particularly the Suez Canal Economic Zone, which offers significant potential to leverage solar and wind energy. Egypt has been particularly successful in announced ammonia investments. The International Energy Agency (IEA) tracks 28 hydrogen projects in Egypt, which are mostly in the concept phase with dedicated renewables (IEA 2024b). Approval was granted to two green hydrogen projects in Ain Sokhna, a Red Sea port town close to the Suez Canal. India's ReNew Power seeks to invest $8 billion to eventually produce an annual 220,000 tonnes of green hydrogen by 2029. An additional $40 billion worth of investments could be underway for the next ten years (Martin 2024).

However, Egypt's hydrogen economy, including green ammonia for fertilisers, will rely heavily on external factors, such as demand market measures — like carbon border adjustment mechanisms and subsidies — to bridge the price gap between green and grey ammonia, making green ammonia production at scale commercially viable for exports and domestic use. The bulk of projected offtake of ammonia, as well as (other) zero-carbon fuels will be after 2030,[11] driven by potential initiatives such as a global maritime levy on shipping fuels. The global market for low-carbon ammonia is estimated to reach 420 million tonnes by 2050, but demand growth is expected to accelerate mainly in the 2030s and 2040s (S&P Global 2023), creating major offtake risks in the short-to medium-term.

[11] The International Maritime Organization aims for 5% uptake of zero-emissions fuel in 2030 (IMO 2024).

Figure 7: Fertiliser import-export and usage for Morocco, Egypt and Kenya, 2010-2021



Source: Authors based on FAOSTAT and OEC

Recent price drops in the (grey) ammonia market further emphasise the importance of subsidies to make early stage green hydrogen and ammonia projects commercially viable (Canel Soria and Soh 2023). A major milestone for Egyptian green ammonia was the award of a 20-year offtake agreement through Germany's auction scheme H2Global, albeit for a relatively modest delivery of 397,000 tonnes of green ammonia between 2027-2033 (Pearce 2024). This H2Global 'pilot auction' award provides a guaranteed offtake, with the German government effectively absorbing the main project risks.

In 2024, Egypt introduced a new wave of incentives aimed at locking in hydrogen investments, seeking to create a more favourable environment for foreign investment. However, Egypt's macroeconomic instability may pose challenges for attracting risk-averse investors. Public debt has grown from 80% of gross domestic product in 2019 to 96% in 2023, causing debt servicing to reach a forecasted 45% of Egypt's budget. Inflation in 2024 was 33% (IMF 2024). Egypt's foreign currency squeeze was partially alleviated by a controversial land deal with the United Araba Emirates (UAE), but it also led to a reduction in the government's stake in key state-owned enterprises including two major fertiliser companies: Abu Qir Fertilisers Company and Misr Fertilisers Production Company (MOPCO; Salah 2024). This may reduce the government's ability to steer the industry's decarbonisation, while retaining the costs linked to input subsidies.

A further challenge, shared across the region, is the low 8% share of renewables in Egypt's energy mix (IRENA 2024). Most green hydrogen projects are being developed with dedicated renewable energy sources. This is essential not only for certain certification but also for commercial viability. However, combined with the strong export focus, there is a risk of creating a 'green enclave' in the Suez Canal's Economic Zone focused on exports, while the rest of Egypt's economy and energy system remains tied to brown industries and fossil-fuel based electricity.

Egypt thus combines significant strengths with substantial risks. Despite these hurdles, Egypt has one of the most compelling cases for establishing a green hydrogen hub. If Egypt's hydrogen economy fails to take off, the financing for hydrogen clusters in other African countries, which share many of the same challenges but may be less favourably positioned, would be in doubt.

Summary of political economy factors for Egypt
Regional: Egypt's H2 strategy has an important regional component as it seeks to supply green hydrogen to the EU and leverage its EU partnership for accelerated investment by European DFIs, such as the EBRD. The country has stronger ties to the Middle East and Europe than to much of Africa, and wants to position itself as a regional hub in the Eastern Mediterranean. **National**: Egypt has significant solar and wind potential, while the Suez Canal Economic Zone provides opportunities for multiple hydrogen applications, including bunkering fuels. The Egyptian government provides ample support to attract investments in hydrogen, yet macroeconomic challenges pose additional barriers. Egypt's established ammonia and fertiliser industry could serve as a foundation for a green ammonia fertiliser value chain, yet these industries may also favour maintaining the current setup. **Sectoral**: There is a substantial domestic market for ammonia driven by high agricultural subsidies, however, these subsidies might be reduced. Numerous foreign-backed hydrogen investments have been announced with support from the Egyptian state. **Overall**: Egypt illustrates the challenges of moving from high-level commitments reliant on foreign investment to tangible implementation. Egyptian green ammonia will largely depend on external factors and will require ample public support to bridge the initial demand gap for green ammonia and low-carbon fertilisers.

Kenya: Newcomer focusing on import substitution

Kenya is an ambitious newcomer in the green hydrogen and fertiliser space. Kenya is a leader in renewable energy, with close to 90% renewables, thanks to its geothermal (47%) and hydropower (34%) capacity (IRENA 2023), and is rapidly expanding wind and solar power. In the past few years under the William Ruto administration, Kenya has sought to position itself as a leader in African climate politics and a key investment destination for green technologies and energy intensive industries.

As an importer of fertilisers (Figure 7), with no domestic production and no active fossil fuel production, Kenya sees green hydrogen as an opportunity to substitute expensive imports and serve its domestic market for subsidised agricultural inputs. While ticking many of the boxes, Kenya's experience also illustrates the challenges in moving from proof of concept to large-scale industrial production, and some of the structural constraints and risk premiums faced by hydrogen developers in African countries.

Kenya's 2023 green hydrogen strategy and roadmap is built around import substitution and food security, essentially trying to hit multiple birds with one stone: increasing food security and resilience, in line with Kenya's ongoing efforts to increase agricultural productivity; improve balance of payments by substituting expensive imports of synthetic fertilisers, and attract foreign investments in green industries, leveraging the country's renewable energy potential.

A difficult road from small- to large-scale green ammonia production

Kenya is one of the first countries to commercially produce green fertilisers, albeit on a small scale. Since late 2023, USA-based Talus Renewables has deployed modular, containerised ammonia and fertiliser production at a major nut farm, producing 200 tons of ammonia per year (Atchison 2023; INC 2024; Sguazzin 2023). The project reportedly is able to produce green ammonia at roughly 75% of the cost of imported fertiliser. This project has provided a valuable proof of concept for African decentralised green ammonia. Modular, decentralised green ammonia may also be a way to scale up green fertiliser production on a fully commercial basis and address the logistics costs by producing on-site. The model also relies on a long-term (10-15 year) businees to business (B2B) offtake agreement, and is therefore limited to a very specific category of farm. However, the smaller funding requirements for decentralized production, compared to billion-dollar large-scale facilities, could make securing financing more manageable. Such decentralised ammonia production is expected to be cost-competitive by 2030 in many more places, especially where transport costs are high, such as in many parts of Africa (Tonelli et al. 2024).

Plans for large-scale green fertiliser production have been announced since COP27 (Conference of the Parties to the UNFCCC 2022), where the Kenyan government and Fortescue Future Industries announced plans for a 300 MW geothermal-powered ammonia and fertiliser plant near Naivasha (Atchison 2022). This project remains in development, with slow progress towards the final investment decision. The initial projected capacity has been revised to 100 MW, all of which could be absorbed domestically if competitive with imports. Beyond import substitution, potential regional markets for (green) fertiliser could be substantial. Yet, reports indicate that it has been challenging to negotiate a low enough cost of geothermal power. Additional challenges are the high upfront costs for electrolysers and high level of debt distress of the country, all contributing to an elevated cost of capital, while the government is in no position to guarantee large-scale investments.

Fertiliser market in crisis

Kenya's green fertiliser plans are linked to the agricultural and input subsidy policies. From 2007 onwards, the Kenyan government initiated an input subsidy programme, with its cereal board directly importing and distributing fertilisers to farmers (Ariga and Jayne 2011; Nduati et al. 2015). Fertiliser subsidies have been a cornerstone of the Ruto government's agriculture policy since 2022 (The Kenya Kwanza Plan 2022), partially driven by the price shock following the

Russian invasion of Ukraine. Still, in 2022, Kenyan fertiliser imports dropped almost 30%. The maize outputs of 2022-23 were also 18% lower than the average of the five previous years.

Subsidised inputs can drive structural demand, like in Egypt, yet they are also vulnerable to policy changes. Kenya's ongoing sovereign debt crisis led to significant budget cuts across agricultural spending in May 2024 (Bii 2024). However, in July 2024, amidst violent protests, additional fertiliser subsidies were announced as part of a supplementary budget (Ambani 2024). Mid-2024, Kenya's cereal board was also embroiled in a scandal for distributing counterfeit domestically-produced fertiliser, while imports reportedly dropped significantly ahead of the revelations (Munda 2024). This illustrates that, even with input subsidies in place, there may be significant additional offtake risks, linked to economic instability, vested interests or even criminal conspiracy.

Overall, Kenya's entry into green fertilisers highlights that, while the country has significant renewable energy resources and a progressive political agenda, moving into large-scale green ammonia production faces challenges. The government's inability to guarantee investments can delay reaching final investment decisions. Kenya's dependence on fertiliser imports and recent market crises build a strong case for domestic production, yet this is further complicated by the instability of input subsidies and economic conditions. Despite these hurdles, Kenya's early adoption of modular and decentralised green ammonia production provides a promising proof of concept for other African nations. Success will require addressing structural constraints, securing stable investment, and navigating agricultural policies and market dynamics.

Summary of political economy factors for Kenya

Regional: Limited regional production capacity in East Africa, with Uganda developing plans for a 100 MW production facility. Kenya's focus is primarily on domestic import substitution to reduce reliance on external supplies.
National: A green hydrogen strategy and roadmap target fertilizer and methanol production for domestic consumption before considering exports. However, Kenya also faces a severe economic crisis. Kenya's dependence on volatile imported fertilizer prices underscores the need for local production, yet high international capital costs and risk premiums pose challenges.
Sectoral: An input subsidy program is in place, but the sector remains highly volatile, exacerbated by a fiscal crisis that heightens offtake risks. Past issues, such as a fake fertiliser scandal and potential vested interests, could undermine efforts to develop a secure and stable market.
Overall: Significant potential exists, supported by several enabling conditions, but success requires de-risking investments and implementing sectoral reforms.

4. Analysing opportunities for an African green fertiliser (r)evolution

This overview illustrates that the opportunities African green fertiliser production depends on much more than geographic features alone. Solar and wind potential are critical for projected levelised cost of hydrogen, but the experience of Morocco, Egypt and Kenya also show the importance of existing industrial capabilities, as well as access to domestic, regional and export markets for fertilisers and hydrogen derivatives.

Having natural resources like solar and wind power potential can provide an incentive for producing green hydrogen, but also the lack of natural resources can be advantageous to draw in policy support. Morocco, for example, sees green hydrogen as a way to hedge against price volatility in international natural gas markets. Kenya's hydrogen economy plans prioritise the substitutions of imports of fossil fuel-derived products like nitrogen fertiliser. In other cases, fossil fuel endowments may compete with green hydrogen developments. In Egypt, green ammonia production for example will compete directly with an established grey ammonia sector, and plans for blue ammonia.

The three cases clearly illustrate that there is no one-size-fits-all model for developing a green fertiliser production. Countries not only need to leverage their natural resources, existing industries and market reach, but also to create favourable investment conditions for these new technologies. This calls for proactive green industrial policies that can shape an economically viable business case, focusing on both backward (energy, financing) and forward linkages (fertiliser industry, transport and logistics, market development).

This overview also indicates that studying green fertiliser production in isolation is of limited value. Even if green fertilisers could potentially supply a substantial African growth market, the viability of early green ammonia projects will likely depend significantly on factors beyond Africa's control. This includes global demand for hydrogen and its derivatives across diverse applications. Adding to this complexity, opportunities for green fertilisers in Africa are as much an agricultural policy issue as they are an energy and industrial policy concern. To fully realise the potential of African green fertilisers, an integrated approach across these domains will be essential.

African green hydrogen in the global hydrogen economy

The opportunities for green fertilisers should be viewed in the wider context of emerging global and regional green hydrogen economies, which are in their infancy. Production facilities worldwide still operate on a piloting scale while the use of green hydrogen in both legacy and new applications is less than 1% (IEA 2023).

This can create additional risk for investors, as long-term offtake remains difficult to assess.[12] Availability and cost of electrolysers, for example, can create additional challenges.[13] Yet it can also create long-term offtake opportunities and early mover premiums for those that are able to secure investments in this early stage of development. This is a key factor driving Moroccan and Egyptian interests, as both countries recognize a clear opportunity to secure a significant share of the emerging global market for hydrogen, its derivatives, and low-carbon industrial products.

Policy and export driven hydrogen economies

Any transition from one energy source to another is a highly complex process involving technological, political and commercial drivers. In the case of green hydrogen, the technology and commercialisation is still very much being developed. With little production taking place, price parity with fossil fuel derived hydrogen is still quite far off. This also means that political and policy drivers (e.g. regulation and incentives) are expected to continue to play an important role in early stage hydrogen initiatives.

For African countries, this means that exports to carbon-regulated markets, where most subsidies are concentrated (Medinilla and Dekeyser 2024), could provide the first reliable offtake opportunities for green hydrogen and ammonia. Subsidies like the H2Global auction, which are also open to international producers, may offer opportunities enticing investors. Both Egypt and Morocco are betting heavily on international markets for large-scale production, for example, and hope to capture a significant portion of the European export market. However, subsidies linked to local consumption of green hydrogen and ammonia are less likely to be available to African companies, making it more challenging to develop a secure business case and offtake for green hydrogen and derivatives.

All this contributes to significant delays in large-scale hydrogen projects in developing countries, including Africa. While hundreds of large-scale projects were announced across Africa at various high-level political events, very few of those are close to reaching a final investment decision. Project delays are common with any new technology, yet developing countries often lag significantly behind. A 2023 review of hydrogen financing by ESMAP estimated that of the hydrogen projects in emerging markets and developing countries — then representing 39% of the global pipeline — only 7% were in an advanced design phase, compared with 93% in developed countries (ESMAP et al. 2023).

While high-level announcements often emphasise Africa's unique potential for green hydrogen, in reality, projects face substantial challenges in achieving economic feasibility and

[12] While the EU’s 2022 REPowerEU plan set an ambitious target of producing and importing 10+10 million tons by 2030, some analysts estimate that in a more efficient scenario, Europe’s consumption could be as low as one fifth of its official target (Agora Energiewende 2023; Medinilla and Dekeyser 2024).

[13] Contrary to projections of a steady reduction in the cost of electrolysers, the cost of production and installation of large-scale electrolysers has reportedly increased by over 50% in 2023-24, largely due to inflation and delays in subsidies in lead markets.

commercial viability. In addition to securing affordable finance it is also about managing regulatory uncertainty, permitting, and fiscal incentives or disincentives.

Infrastructure and additionality

A major challenge for all energy intensive industries is the limited availability and reliability of energy infrastructure. In many cases, grid-connected hydrogen production is either not feasible, or too expensive. Many hydrogen projects are therefore being developed with dedicated renewables (so-called 'captive systems'). Examples include the modular green fertiliser production by Talus renewables in Kenya, but also OCP's planned $7 billion investment in green ammonia production in Morocco. Captive systems help reduce overall risk for hydrogen projects and ensure the additionality required for green certification. Yet at the same time, they risk developing into enclave industries, especially if most of the hydrogen or derivatives production is destined for exports.

Regional integration

The development of green hydrogen and its application in fertiliser production can enhance regional trade, reduce dependency on imports, and foster economic integration. Morocco, Egypt and Kenya have different opportunities regionally. Morocco has strong regional prospects through a possible pipeline to the EU market, a planned pipeline for gas imports to Nigeria that could double for green hydrogen exports, and invests in fertiliser production in some sub-Saharan African countries. Egypt has fewer direct regional opportunities, but it aims to refuel ships passing through its Suez Canal. Kenya requires regional integration the most: Its small domestic market necessitates regional markets, and cooperation could allow for the distribution of different segments of the value chain across the region rather than building the entire chain from scratch independently.

De-risking hydrogen investments

Risk is a critical factor in early hydrogen projects. Up to 36% of the levelized cost of hydrogen comes from annualised capital expenditure (Hydrogen Europe 2024), making hydrogen economy projects particularly sensitive to changes in financing cost. In addition to offtake risk — largely due to long-term market uncertainty — hydrogen project developers cite political and regulatory risks; infrastructure risks; permitting risks; technology risks; and macroeconomic risks (WB and OECD 2023), many of which can be amplified in developing country settings, where capital often carries a significant country risk premium.

All this highlights the importance of smart green industrial policy and long-term planning to position economies to benefit from early hydrogen investments, while also balancing multiple objectives, including:

- Attracting external finance for hydrogen projects;
- Securing export market off-take;
- Accelerating access to clean and affordable energy;
- Creating opportunities for local industries and job creation; and
- Minimising negative impacts on ecosystems.

In short, while African green hydrogen holds promise within the emerging global hydrogen economy, the path to realising their potential is fraught with challenges. The high upfront investments, technological and infrastructural constraints, and the complex policy landscape require careful navigation. African nations are taking proactive steps to secure early investments and position themselves in the global market. Yet, while natural resource endowments are a significant advantage, African economies face structural disadvantages in many other respects compared to advanced economies.

Green industrial policy meets agricultural reforms

Developing the underserved African market for nitrogen fertiliser can generate significant local demand for green hydrogen while addressing some of the risks and drawbacks of primarily export-oriented hydrogen economies. Achieving this will require a stronger integration of green industrial policies with agricultural reforms. Although agricultural and industrial policies are often disconnected, usually to the disadvantage of agriculture, the green transition offers a chance to align and integrate these agendas more effectively.

Historically, after independence, many African countries financed rapid industrialisation by taxing agriculture through overvalued exchange rates, making imports cheaper but exports harder, reflecting a desire to maintain urban stability with low food prices. Today, African governments also subsidise and invest less in their agriculture than other regions, despite continental investment targets. Many African countries continue to prioritize industrial development over agriculture (Resnick 2020), explaining partly why agricultural reform in Africa has mostly been a failure.

Some African countries — often more democratic ones — have adopted stronger pro-rural policies and established agricultural support. Input subsidies are a popular means of such agricultural support as they are highly visible (Resnick 2020). But they are often done in countries lacking fertiliser production, hence such programmes mostly subsidise fertiliser imports and are again disconnected from industrial policy.

The past decade saw a focus on agro-industrial policy, which aims to add value to agriculture through industry and develop downstream sectors. Such agro-industrial policy is intended to rectify coordination failures, address externalities and facilitate spillovers, with the state as a central actor (Resnick 2020). Agro-industrial parks are a recent example of efforts to link industrial development with agriculture growth, and vice versa, by clustering services and infrastructure to support agricultural commercialisation.

Industrial policies are experiencing a resurgence in Africa, particularly as countries position themselves for reaping the benefits from the green transition and avoid being left out again of new global value chains. At the same time, agriculture generally lags. More ambitious agro-industrial policies could bridge the gap between sectors and foster greater integration, exploiting synergies between the two. Importantly, such agro-industrial policy should ideally be part of a wider agricultural reform, as the case of fertiliser subsidies show: often, such subsidies lead to overapplication and waste, with negative financial and environmental effects. The current state of African agriculture is not due to any single issue, so a comprehensive, integrated approach is needed

Ambitious agro-industrial policies would benefit from addressing the entire food system, including better farm management, market integration, social organisation, access to finance, better infrastructure and supporting food processing, but also the administrative and institutional capacity to support change and growth. This undertaking will inevitably open up a host of political economy factors, including the need to reverse long-standing biases against agriculture.

5. Concluding remarks

Africa is widely viewed as full of potential to benefit from the green hydrogen transition thanks to its great renewable energy potential. This potential, however, is just one piece of a complex puzzle. There are distinct opportunities for first movers who can build on existing industrial capabilities, established domestic and export markets, and/or create favorable conditions for early investment.

Different countries can prioritise different pathways into green hydrogen, each offering unique advantages and distinct challenges. Morocco's solar potential and strategic location near the EU, Egypt's high domestic demand and the Suez Canal's strategic position, and Kenya's renewable energy resources all highlight the diverse routes available to different African countries to establish their green hydrogen economy.

Perhaps uniquely African is the role of fertilisers in establishing green hydrogen sectors: using green hydrogen to produce fertilisers can decarbonise existing facilities, enable local production to substitute imports, and leverage 'brown' capabilities to jumpstart green industries. By integrating industrial policy with agricultural reform, an unique opportunity emerges to leverage renewable energy potential to drive long-sought agricultural transformation and to address food security, environmental sustainability and economic development.

Yet each trajectory comes with its own set of complexities, emphasising the importance of looking beyond the simplified technical business case at the industrial and agricultural dynamics that can help or hamper the scaling up of green hydrogen and fertiliser production.

6. Recommendations

For countries looking to move into green hydrogen production

1. **Develop more balanced hydrogen roadmaps**, better factoring offtake risk from export markets, and prioritising domestic applications and market development, to minimise

risks and maximise opportunities. These roadmaps could place greater emphasis on integrating green hydrogen plans with other sectors, such as agriculture, by fostering connections along the value chain.

2. **Develop industrial policies tailored for early stage hydrogen economies**. This means a good balance between special incentives for green energy and hydrogen economies, energy policy measures to enable low-cost, reliable and certifiable green energy supply, market development for hydrogen, ammonia, and the horizontal measures to enable high-tech industrial investments.
3. **Invest in innovation partnerships and research and development** as well as project deals. Given the early stage of green hydrogen economies, research and development for domestic hydrogen applications, skills development to supply both pilot and full-scale projects play an important role in positioning countries as investment destinations.
4. **Support sector and cluster coordination for green hydrogen and derivatives,** including public-private dialogue, aiming to foster integration and efficiency and tackle sector-wide obstacles jointly. This would help secure offtake agreements.

For international partners, funders and investors

1. **Leverage concessional finance for early-stage projects:** Use concessional loans, blended finance, and grants to reduce the financial burden for African countries establishing green hydrogen projects, helping to close the cost gap between green and grey ammonia, and reducing risk perception premiums, building on the example of the H2Global pilot auction
2. **Develop a stronger external investment strategy for green energy-intensive industries in Africa,** focusing on creating domestic opportunities through supply chain diversification, avoiding a purely export oriented green hydrogen economies. This includes focusing on more downstream products including nitrate fertilisers as a way to stabilise offtake, lower costs and reduce dependence on global markets.
3. **Establish a critical mass of pilot projects in African countries** to increase investor confidence, demonstrate commercial viability, and experiment with different financing mechanisms.
4. **Support infrastructure development for regional integration**: Fund the development of regional transportation and logistics corridors to improve connectivity between African countries, enabling efficient distribution of hydrogen and fertiliser products across borders and enhancing regional market access.

For the research community

1. **Invest in political economy analysis of hydrogen economies and supply chains in African countries,** which looks beyond a country's potential in green hydrogen but also regards its economic and political feasibility and the distribution of benefits.
2. **Map regional hydrogen and derivatives opportunities and bottlenecks,** with special attention to the roles of logistics corridors in developing regional markets.
3. **Develop frameworks and recommendations for development finance for energy-intensive industries, focusing on de-risking early investments**: This should include

insights into innovative financing models, risk-sharing mechanisms, and policy incentives that make green hydrogen and fertiliser projects more attractive to both public and private investors, especially in high-risk contexts.

References

Agora Energiewende. 2023. *Breaking free from fossil gas. A new path to a climate-neutral Europe*. Study. Berlin.

Ahmed, N. and Cockayne, J. 2024. *Morocco Renewables Capacity Hits 4.6GW With 270MW Wind Start-Up*. 67(43). Nicosia: Middle East Economic Survey (MEES).

Ambani, B. 2023. Hydropower generation at record low on drought. Kenya Edition. *Nation*. Nairobi.

Ambani, B. 2024. Farmers get Sh2.5bn extra fertiliser subsidy in mini-budget. ePaper, Kenya edition. *Nation*. Nairobi.

Ariga, J. and Jayne, T.S. 2011. Fertilizer in Kenya: Factors Driving the Increase in Usage by Smallholder Farmers. In Chuhan-Pole, P. and Angwafo, M., *Yes Africa Can, success stories from a dynamic continent*, Chapter 16: 269-288. Washington, DC: The World Bank.

Atchison, J. 2022. *COP27: raised ambitions for Africa*. Brooklyn, NY: Ammonia Energy Association.

Atchison, J. 2023. *Talus Renewables: modular, renewable fertilizers in Kenya & Iowa*. Brooklyn, NY: Ammonia Energy Association.

Atchison, J. 2024. *$37 billion in Egyptian ammonia investments*. Brooklyn, NY: Ammonia Energy Association.

AU. 2014. *Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods*. Addis Ababa: African Union.

Bii, B. 2024. Subsidised fertiliser budget cut has farmers worried. ePaper, Kenya edition. *Nation*. Nairobi.

Bounjou, K. and El Mouadden Lalami, W. 2023. *Morocco's Energy Oasis: An Analysis of the Renewable Energy Legislation Overhaul*. New Delhi: The Indian Journal of Projects, Infrastructure, and Energy Law (IJPIEL).

Busari, S. 2022. *'People are begging us to sell.' Africa's richest man opens huge fertilizer plant as food crisis looms*. Connecting Africa. Atlanta, GA: CNN.

Canel Soria, S. and Soh, S. 2023. *Analysis: Global ammonia prices fall 50% on year, sparking concerns over future low-carbon market*. New York, NY: S&P Global.

EBRD. 2024. *EBRD Egypt H2 Strategy FULL Version - Rev 10*. London: European Bank for Reconstruction and Development.

EI. 2024. *Statistical Review of World Energy*. London: Energy Institution.

Egypt Today. 2024. *Egypt to increase subsidized fertilizer prices by up to 30%*. Caito: IBA media.

Eljechtimi, A. 2023. *Morocco's OCP plans $7 billion green ammonia plant to avert supply problems*. Climate & Energy. London: Reuters.

Enterprise. 2024. *Our new national low carbon strategy lays out some practical steps toward scaling up green and blue hydrogen production*. Going green. London.

EWI, AUC, BUE and UNI Koeln. 2023. *Cluster analysis for green hydrogen in Egypt A study from the project "Building a Sustainable Energy Future" (BaSEF)*. Cologne: Institute of Energy Economics at the University of Cologne.

FAO. 2024. *FAOSTAT Data*. Rome: Food and Agriculture Organization.

Fortescue. 2024. *OCP and Fortescue to partner to develop green energy, hydrogen and ammonia in Morocco*. Perth.

Gazzon, A., Robert, J.-G., Decoopman, C., Lévêque, E., Dinard, A. and Zeddou, N. 2024. *Job Creation and Skills Development During the Energy Transition – Morocco*. ESMAP Paper. Washinton, DC: World Bank Group.

Giller, K.E. 2020. The Food Security Conundrum of sub-Saharan Africa. *Global Food Security*, 26: 100431. ScienceDirect. Amsterdam: Elsevier. *https://doi.org/10.1016/j.gfs.2020.100431*

Guèdègbé, T. and Doukkali, M.R. 2018. *Fertilizer use in Africa: A Price Issue*. Policy Brief no. 18/27. Rabat: OCP Policy Center.

Hydrogen Europe. 2024. *Clean Hydrogen Production Pathways- Report 2024*. Brussels.

Holden, S.T. 2018. Fertilizer and sustainable intensification in Sub-Saharan Africa. Global Food Security, 18: 20-26. *ScienceDirect*. Amsterdam: Elsevier.

Hostert, D. 2024. *New Energy Outlook 2024*. London: BloombergNEF (BNEF).

Humperdinck, S., Stork, M., Reiser, M. and Schimmel, M. 2023. *Roadmap for the European Fertilizer Industry*. Final version. Prepared for Fertilizers Europe. Utrecht: Guidehouse Netherlands B.V.

IEA. 2022a. *Global Hydrogen Review 2022*. Reports. Paris: International Energy Agency.

IEA. 2022b. *Skills Development and Inclusivity for Clean Energy Transitions*. Paris: International Energy Agency.

IEA. 2024a. *Hydrogen Production and Infrastructure Projects Database*. Paris: International Energy Agency.

IEA. 2024b. *Morocco*. Paris: International Energy Agency.

IMF. 2024. *Inflation rate, average consumer prices*. Washington, DC: International Monetary Fund.

IMO. 2024. *IMO's work to cut GHG emissions from ships*. London: International maritime Organization.

INC. 2024. *Kenya Nut Company Presents Modular Green Nitrogen Fertiliser Production Project – An Elixir of Life for the Kenya Macadamia Industry for the INC Sustainability Award*. Reus: International Nut & Dried Fruit Council.

IRENA. 2023. *Energy Profile: Kenya – Country indicators and SDGs*. Abu Dhabi: International Renewable Energy Agency.

IRENA. 2024. *Energy Profile: Egypt – Country indicators and SDGs*. Abu Dhabi: International Renewable Energy Agency.

KfW. 2024. *Renewable energy sources in Morocco*. Frankfurt: Kreditanstalt für Wiederaufbau.

Kurdi, S., Mahmoud, M., Abay, K.A. and Breisinger, C. 2020. *Too much of a good thing? Evidence that fertilizer subsidies lead to overapplication in Egypt*. MENA RP Working Paper 27. Washington, DC: International Food Policy Research Institute (IFPRI). *https://doi.org/10.2499/p15738coll2.133652*

Jayne, T.S., Mason, N.M., Burke, W.J. and Ariga, J. 2018. Review: Taking stock of Africa's second-generation agricultural input subsidy programs. *Food Policy*, 75: 1-14. ScienceDirect. Amsterdam: Elsevier. *https://doi.org/10.1016/j.foodpol.2018.01.003*

Kyriakou, V., Garagounis, I., Vourros, A., Vasileiou, E. and Stoukides, M. 2020. An Electrochemical Haber-Bosch Process. *50 Joule*, 4(1): 142-158. Cambridge, MA and Amsterdam: Cell Press and Elsevier. *https://doi.org/10.1016/j.joule.2019.10.006*

Lassaletta, L., Billen, G., Grizzetti, B., Anglade, J. and Garnier, J. 2014. *50 year trends in nitrogen use efficiency of world cropping systems: the relationship between yield and nitrogen input to cropland*. Environmental Research Letters. 9(10): 105011. JRC91602. Brussels: European Commission (EC).

Lema, R. Fu, X. and Rabellotti, R. 2020. Green windows of opportunity: latecomer development in the age of transformation toward sustainability. *Industrial and Corporate Change*, 29(5): 1193–1209. Kettering: Oxfor Academic. *https://doi.org/10.1093/icc/dtaa044*

Machado, P. 2024. *European firms get 'Moroccan Offer' for green NH3*. Latest market news. London: Argus.

Maina, M. 2024. *Western Sahara, the pawn in Kenya's rapprochement with Morocco*. Paris: The Africa Report.

Martin, P. 2024c. *Egypt inks seven more agreements for green hydrogen projects, worth $40bn over next ten years*. London: Hydrogen Insite.

MASEN. 2024. *Green Hydrogen, Moroccan offer*. Rabat: Moroccan Agency for Sustainable Energy.

Medinilla, A. and Byiers, B. 2023. *The political economy of green industrialisation in Africa*. ECDPM Discussion paper 363. Maastricht: ECDPM.

Medinilla, A. and Dekeyser, K. 2024. *Green hydrogen: The future of African industrialisation?* ECDPM Guide. Maastricht: ECDPM.

MEM. 2021. *Feuille de route - Hydrogène Vert - Vecteur de Transition Énergétique et de Croissance Durable*. Rabat: Ministère de la Transition Énergétique et du Développement Durable, Royaume du Maroc.

Moharram, N.A., Tarek, A., Gaber, M. and Bayoumi, S. 2022. Brief review on Egypt's renewable energy current status and future vision. *Energy Reports*, 8(9): 165-172. ScienceDirect. Amsterdam: Elsevier.

Munda, C. 2024. How fertiliser imports fell 66 percent ahead of scandal. *Business Daily*. Nairobi.

Nduati, M., Ncube, P., Roberts, S. and Vilakazi, T. 2015. *Non-confidential final report: Market inquiry on fertilizer in Kenya*. Johannesburg: Competition Authority of Kenya and Centre for Competition, Regulation and Economic Development, University of Johannesburg.

OCP. 2022. *OCP Group launches a $13 billion Green Investment Strategy*. Casablanca.

OCP. 2024a. *OCP S.A. successfully completed a bond issue on the international markets for 2.0 billion USD*. Casablanca.

OCP. 2024b. *OCP Group Secure €200 Million Green Financing from KfW*. Casablanca.

OEC. 2023. *Profile Country: Egypt*. Cambridge, MA: Observatory of Economic Complexity.

OEC. 2024. *Ammonia in Egypt*. Cambridge, MA: Observatory of Economic Complexity.

Pearce, O. 2024. *Fertiglobe success in H2Global pilot auction marks milestone in renewable ammonia supply for EU*. New York, NY: Ammonia Energy Association.

ReSAKSS. 2023. *Conference*: *African Food Systems Transformation and the Post-Malabo Agenda*. November 27-29, 2023. Concept Note. Kigali and Addis Ababa: Regional Strategic Analysis and Knowledge Support System and African Union.

Resnick, D. 2020. The political economy of agricultural policy in Africa: Implications for agrifood system transformation. In Resnick, D., Diao, X. and Tadesse, G. (Eds). 2020. *Annual trends and outlook report*: *Sustaining Africa's agrifood system transformation*: *The role of public policies*, 14: Pp. 174-181. Washington, DC and Kigali: International Food Policy Research Institute (IFPRI) and AKADEMIYA2063.

Rice, B. and Vos, R. 2024. *Who's afraid of high fertilizer prices?* IFPRI Blog.

Rikabi, R. 2024. *Green Hydrogen Imports into Europe*: *An Assessment of Potential Sources*. OIES Paper ET32. Oxford: Oxford Institute for Energy Studies.

Ritchie, H. 2021. *Can we reduce fertilizer use without sacrificing food production?* Oxford: Our World in Data.

Ritchie, H. 2022. *Increasing agricultural productivity across Sub-Saharan Africa is one of the most important problems this century*. Oxford: Our World in Data.

S&P Global. 2023. *Ammonia Market to Triple by 2050 with Nearly All Growth Coming from Low-Carbon Supply*. Press. New York, NY.

Salah, F. 2024. Government fears losing control over state-owned companies amid IPO programme. *Daily News Egypt*. Giza.

Saleh, H. 2023. Ukraine war fallout benefits one of world's biggest fertiliser groups. *Financial Times*. London.

Schelling, K. (ed.). 2023. *Green Hydrogen to Undercut Gray Sibling by End of Decade*. London: BloombergNEF (BNEF).

Schmitt, K., Pehl, P., Höpp, J., Knicker, F. and Schreider, A. 2022. *Baseline study on the potential for Power-to-X / Green Hydrogen in Kenya*. Nairobi and Bonn: Ministry of Energy, Kenya and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

SDPD and UN ESCWA. 2018. Case Study on Policy Reforms to Promote Renewable Energy in Morocco. New York and Beirut: Sustainable Development Policies Division and United Nations Economic and Social Commission for Western Asia.

Sguazzin, A. 2023. *Kenya Farm to Host First on Site-Hydrogen-to-Fertilizer Plant, Iowa to Follow*. Green. New York, NY: Bloomberg.

Shah, S. and Odionye, N. 2021. *It's Time to Expand Fertilizer Manufacturing Across Africa*. Berkley, CA: Breakthrough Institute.

Sinaceur, O. 2023. *Morocco*: *A new legal framework for Independent Power Producers*. Alert. New York, NY: White&Case.

SIS. 2024. *Hydrogen Strategy expected to boost Egypt's GDP to around $18 billion by 2040*. Media Center. Cairo: State Information Service.

Srahna, I. 2024. *OCP revenue dips in 2023, but profitability holds strong*. Morocco's General Consulate in Rome: Hepsress.

Takouleu, J.M. 2023. *EGYPT: the first green methanol-powered ship drops anchor in Port Said*. Paris: Afrik 21.

Tanchum, M. 2022a. *Morocco's New Challenges as a Gatekeeper of the World's Food Supply: The Geopolitics, Economics, and Sustainability of OCP's Global Fertilizer Exports*. Washington, DC: Middle East Institute.

Tanchum, M. 2022b. *Morocco - a top fertiliser producer - could hold a key to the world's food supply*. Melbourne: The Conversation.

The Economist. 2023. *A huge Norwegian phosphate rock find is a boon for Europe*. London.

The Kenya Kwanza Plan 2022. *The Bottom Up Economic Tranformation Agenda 2022-2027*. Johannesburg: Africa Check.

The Royal Society. 2020. *Ammonia: zero-carbon fertiliser, fuel and energy store*. Policy Briefing. London: The Royal Society of London for Improving Natural Knowledge.

The Star. 2022. *Kenya to get more than fertiliser imports from Morocco – Experts*. Nairobi.

Tonelli, D., Rosa, L., Gabrielli, P., parente, A. and Contino, F. 2024. Cost-competitive decentralized ammonia fertilizer production can increase food security. *Nature Food*, 5: 469–479. London: Nature Portfolio. *https://doi.org/10.1038/s43016-024-00979-y*

UN COMTRADE. 2024. *UN COMTRADE database*. New York, NY: United Nations.

Van Ittersum, M.K., van Bussel, L.G.J. and Cassman, K.G. Scholes, R.J. (eds.). 2016. Can sub-Saharan Africa feed itself? Research article. *PNAS*, 113(52): 14964-14969. Washington, DC: Proceedings of the National Academy of Sciences. *https://doi.org/10.1073/pnas.1610359113*

WB and OECD. 2023. *Scaling hydrogen, financing for development*. Washington, DC and Paris: Bank for Reconstruction and Development/The World Bank and the Organisation for Economic Co-operation and Development.

Williams, D.R., Clark, M., Buchanan, G.M., Ficetola, G.F., Rondinini, C. and Tilman, D. 2020. Proactive conservation to prevent habitat losses to agricultural expansion. *Nature Sustainability*, 4: 314–322. London: Nature Portfolio. *https://doi.org/10.1038/s41893-020-00656-5*

Zhang, X., Davidson, E.A., Mauzerall, D.L., Searchinger, T.D., Dumas, P. and Shen, Y. 2015. Managing nitrogen for sustainable development. *Nature* 528: 51–59. Berlin: Nature Portfolio. *https://doi.org/10.1038/nature15743*

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