

Supplementary S4: Full scenario narratives.

Scenarios of future land use change in rural Mozambique: 2015-2035.

The development of scenarios was initiated with two workshops in Mozambique, which sought to gather information about the most important drivers of change affecting livelihoods and land use dynamics in rural Mozambique. The workshops were attended by a range of stakeholders from different backgrounds, all with interest in improving the wellbeing for rural communities. Stakeholders were asked to discuss drivers in five main categories (societal, environment, economy, technology, and policy) and to rank them in order of importance for the impact on rural livelihoods. Data from these workshops were used to develop the initial rough drafts of the narratives for a set of scenarios that explore alternative and plausible futures for rural Mozambique. Full data can be consulted in: Zorrilla-Miras, P.; Matediane, J.; Mahamane, M.; Nhantumbo, I.; Varela, R.; Metzger, M.J.; Patenaude, G. *Scenarios of future land use change in Mozambique (2014 and 2015)*; NERC Environmental Information Data Centre, 2018.

The next stage implied further input from another set of stakeholder workshops in Mozambique to check the plausibility, coherence, and salience of these scenarios. The scenarios were also refined and downscaled to produce a finer-scale picture of land cover changes (e.g., % increase or decrease in cash-crop agriculture) for each of the three regions under study based on inputs from workshops. Finally, the narratives were refined into a final suite of storylines. We first present a summary of the narrative of each scenario, followed by tables describing them, and finally we present the full description of the storylines of each scenario.

1. Summary of the scenarios narratives

1.1. Scenario A: Large private investments scenario

Synthesis: The main idea of this scenario is that public policies promote the international and large scale private sector as the main development engine and a reduced local voice (participation) accompanied with low implementation of social and environmental policy provisions.

Approach: This scenario adopts a globalized approach to resource management and, as a consequence, more of Mozambique's land is under private long-term leases and concessions by 2035. This includes agricultural and forested areas but also a significant increase in mined areas. The support of the government to large (favoring foreign) capital investment, with an ineffective land use policy and an increase in technological advances, has resulted in greater migration from rural populations to urban areas. Although capital investment has considerably increased Mozambique's Gross Domestic Product (GDP), equality in society declines.

Social and Environmental Policies: State social and environmental policy implementation is not very effective due to the lack of funding at regional levels. However, legislation exists to protect, for example, habitats, the lack of enforcement often results in an abuse of the system.

Public extension services: are scarce, while private extension services increase in relation to big farming initiatives. Both services encourage farmers and foresters to increase productivity for selling in regional and international markets rather than for community self-sufficiency.

Changing on Livelihood: most rural communities (those not benefiting from large investments) do not improve their livelihoods: food security is their main concern. Some urban families improve their well-being, but a large number remain very poor.

Wildlife/Natural Resource and Environment: There are some areas of protected wildlife, but as with the rest of Mozambique's natural resources, these areas are used to generate income for state and large private enterprises. Environmental quality reduces in many habitats and ecosystems as a result of intense management; this makes it harder for many local communities to improve their wellbeing.

Mozambique's relation with its neighboring countries: is improved through greater trading partnerships; furthermore, several global countries see Mozambique as an important country for trade, including China, many EU countries, Brazil and India.

1.2. Scenario B: Small holder promotion

Synthesis: The main idea that runs in this scenario is the increase of local power (investment in small and medium enterprises) and the importance of public policies to drive this development agenda.

Approach: This scenario is in contrast to Scenario A and therefore favor regional and local community empowerment in many of Mozambique's resources over overseas private investment. The proliferation of internet-based technologies, even in rural areas, increases the voice of local organizations, which push the government to increase the public involvement in rural development, with an improvement of public services. There is also a real commitment of the government to improve education and training, and to practice a more open and transparent mode of governance. However, this is not a utopian dream, it is based on a realistic view that Mozambique's society is better served by looking inwards rather than trying to compete in a global economy.

Social and Environmental Policies: education and training, health, and environmental policies are a priority for the government (in part because of a demand from society) and thus obtain great achievements.

Public extension services are very successful and follow conservation agriculture guidelines.

Changing on Livelihood: most rural communities improve their livelihoods: food sovereignty is achieved due to a sustainable and small scale agriculture production focus on extension services.

Wildlife/Natural Resource and Environment: Public support to communities has resulted in sustainable forest management, which seeks to protect plant and animal diversity through harvest levels that respect ecosystem integrity. There are many areas of protected wildlife, and some are used for community-controlled eco-tourism. This Scenario presents the most favorable for the environmental aspects of Mozambique.

Mozambique's relation with its neighboring countries welcomes investment from the latter as well as European and other world powers; however, this arrangement is made on the basis and requirement that companies respect local communities' rights and share the development profits. Mozambique provides a model for other African countries seeking foreign investment without jeopardizing their natural resources.

1.3. Scenario C: Intermediate scenario

Synthesis: This scenario lies somewhere between scenarios A and B and adopts a balance between a more globalized approach versus one with regional and local community empowerment and resource management. Consequently, large parts of Mozambique's land are in long term private leases or concessions. At the same time an improvement in education, empowerment and environmental stewardship allows some communities to self-organise and improve their well-being.

Approach: the government supports large capital investment favoring foreign firms but also puts an effort on improving social and environmental policies. Internet-based technology has enabled better democracy and allowed community empowerment to flourish in some areas of Mozambique, although the state still maintains a high control of resources and power.

Social and Environmental Policies: The government economic resources are higher than in 2015 because a greater percentage of income levied from taxes on international extractive projects. Although a big part of state income is derived for the construction of the necessary infrastructure for those investments, the higher availability enables the improvement of extension services and other public policies. This has special importance in some districts that improve public services and community empowerment. International NGOs and official aid contribute also to those activities at district scale.

Agricultural extension services: are mainly dedicated to commercial agriculture.

Changing on Livelihood: some rural communities' benefit from large commercial projects and other communities from the improvement of social services, food security continues being the main concern for the rest of the communities.

Wildlife/Natural Resource and Environment: There are several areas of protected wildlife, but the rest of Mozambique's natural resources are used to generate income for state, private and community enterprises. Environmental quality reduces in many habitats and ecosystems as a result of intense use; but in other areas local communities thrive due to sustainable resources management.

Mozambique's relation with its neighboring countries: has increased its status in global politics due to the balance it is trying to achieve with private investment and natural resource management. Many European countries in particular support this approach although some countries like China lobby hard to be allowed to have greater access to Mozambique's natural resources.

Table S1. Summary and figures of the main drivers of chain for each scenario in rural Mozambique in 2035.

	Drivers										
	Societal			Technology			Environment	Economic		Policy and politics	
	Social services	Employment		Increasing access to technologies Farming	Information and commu- nications technology	Individuals using the Internet:	Nature degradation	Annual Increase national GDP	Families income	Policy implementation	Political involvement from society
Baseline	% of GDP Government expenditure on education: 6.5%	Pupil- teacher ratio in primary education : 52.4	Unemployment: 25% Paid employment jobs (% of total employed): 4%	15% of farmers had access to extension services	Mobile- cellular subscriptions (per 100 inhabitants): 40%-72%	20%	Forest deforestation (1.9–3.2%/yr) and degradation (2–3%/yr)	+6%	Minimum Wage per Month (Agriculture and Fores- try): 83 US\$	435 forest officers in Mozambique (184,274 ha/forest officer)	Farmers participatin g in associations : 2.8%
Scenario A	% of GDP on education: 6.5%	Pupil- teacher ratio: 52	40% Paid employment jobs in urban areas, 9% in rural areas	25% of farmers	Mobile- cellular: 80%	Internet: 40%	Deforestation (0.5–2.5%) and degradation (4–6%/yr)	8%	83 US\$ (3196 MZM)	1 forest officer per 180,000 ha	Low (5%)
Scenario B	% of GDP on education: 12%	Pupil- teacher ratio: 25	25% Paid employment jobs in urban areas, 20% in rural area	80% of farmers	Mobile- cellular: 95%	Internet: 90%	Deforestation (0.1–0.9%) and degradation (1–1.5%/yr)	4%	115 US\$ (4500 MZM)	1 forest officer per 18,000 ha	High (40%)
Scenario C	% of GDP on education: 9%	Pupil- teacher ratio: 45	25% Paid employment jobs in urban areas, 15% in rural area	40% of farmers	Mobile- cellular: 90%	Internet: 60%	Deforestation (0.2–1.7%) and degradation (2–3%/yr)	6%	105 US\$ (4000 MZM)	1 forest officer per 90.000 ha	Medium (20%)
Data source for baseline (year)	1 (2013)	2 (2017)	3 (2018) 4 (2013)	5 (2014)	6 (2015- 2017)	6 (2017)	7,8,9, (2007- 2018)	10 (2008- 2018, average)	11 (2015)	12 (2004)	11 (2015)

1. <http://data.un.org/en/iso/mz.html> Accessed on 2018/08/098.
2. <https://data.worldbank.org/indicator/SE.PRM.ENRL.TC.ZS?locations=MZ> . Accessed on 2018/08/08. (UNESCO Institute for Statistics (Data source: uis.unesco.org).
3. <http://data.un.org/en/iso/mz.html> . Accessed on 2018/08/08.
4. <http://data.worldbank.org/country/mozambique> . Accessed on 2018/08/08.

5. Plano operacional para o desenvolvimento agrário de Moçambique (2015 - 2019). 2015. Ministério da Agricultura e Segurança Alimentar. Republica de Moçambique.
6. https://data.worldbank.org/indicator/IT.CEL.SETS.P2?locations=MZ&year_high_desc=false . Accessed on 2018/08/08.
7. Marzoli, A., 2007. Inventário florestal nacional: avaliação integrada da floresta em Moçambique (AIFM). Direção Nacional de Terras e Florestas, Maputo, Mozambique.
8. Direção Nacional de Terras e Florestas. 2018. Inventário florestal nacional. Ministério Da Terra, Ambiente E Desenvolvimento Rural. República De Moçambique. Maputo, Mozambique.
9. Ryan, C.M., Berry, N.J., Joshi, N., 2014. Quantifying the causes of deforestation and degradation and creating transparent REDD+ baselines: a method and case study from central Mozambique. Appl. Geogr. 53, 45–54.
10. <https://data.worldbank.org/country/mozambique> . Accessed on 2018/08/08. Data: 2008-2018.
11. Anuário de Estatísticas Agrárias 2015. Direcção de Planificação e Cooperação Internacional. Ministério da Agricultura e Segurança Alimentar. República De Moçambique. Maputo.
12. Estratégia para a Fiscalização Participativa de Florestas e Fauna Bravia em Moçambique (2005). Portal de governo de Mozambique. Ministerio de Trabalho. Maputo.

Table S2. Figures from Table S1 are qualitatively translated in this table for its representation in Figure 4A of main text of the paper.

	Societal		Technology		Environment	Economic		Policy and politics	
	Education	Employment	Agriculture extension services	Internet	Nature conservation	GDP	Families income	Policy implementation	Political involvement from society
Scenario A	2.6	2.3	1.6	4.2	1.3	5.0	3.6	0.5	0.6
Scenario B	5.0	5.0	5.0	5.0	5.0	2.5	5.0	5.0	5.0
Scenario C	3.0	3.8	2.5	4.7	2.5	3.8	4.4	1.0	2.5

Table S3. Summary of the Scenarios of land use change in rural Mozambique in 2035.

SCENARIO A Large private investments	SCENARIO B Small holder promotion	SCENARIO C Intermediate scenario
Societal aspects		
<ul style="list-style-type: none"> • Population increases to 44 million hab. • Massive urbanization at the expense of rural migration • Social services are not promoted. The “fund for district development” (7 billion) does not yield the expected results. • National civil society organisations have decreasing influence. • Not effective at enabling self-organization of citizens • Most rural families do not improve their livelihoods because of scarce education, training, and extension services. • The implementation of land law will be yet to be consolidated. • Deficient impact between men and women favouring men. 	<ul style="list-style-type: none"> • Population increases to 38 million hab. • Urban/rural population ratio remains stable • State run social services (as energy, water, schools, extension services, hospitals, health care clinics, etc.) are empowered and effective, often in tandem with NGOs. • Civil society organisations are effective in enabling communities to have a voice in local and national democracy. • Empowered and self-organized citizens • Livelihoods improve markedly in rural areas (in great part due to the improved social services). • Decentralization and institutional empowerment are reinforced. • The political environment encourages entrepreneurship of women, men, and youth, which improves the situation of women (together with improved social services). 	<ul style="list-style-type: none"> • Population increases to 41 million hab. • Massive urbanization at the expense of rural migration • State tries to run social services, however only some districts obtain successful results. • Some civil society organisations are effective in some districts but large international companies are also effective. • Gradual increase in civil society organisations • Some urban and rural families improve their situation, but food security remains as a big concern for many rural families. • The land use policies are well designed yet not sufficiently absorbed by stakeholders. • Big companies favour jobs for men, however the success of some social services and the entrepreneurial environment are beneficial for women.

- | | | |
|---|--|--|
| <ul style="list-style-type: none"> • Culture: New values and no preservation of local culture. • The government does not push for mega projects to train their workers, so the local population is not hired. | <ul style="list-style-type: none"> • Culture: stable preservation of local culture. • The state secures the education of local employees as a way to provide the workforce with the new investments coming to country. | <ul style="list-style-type: none"> • Culture: Moderate preservation of local culture. • The state secures the education of local employees as a way to provide a workforce to the new investments coming to the country. An inclusive and integrated training is achieved. |
|---|--|--|

Technology aspects

- | | | |
|---|--|--|
| <ul style="list-style-type: none"> • Technology being used in large scale companies and contracted excluding small farmers. | <ul style="list-style-type: none"> • Associations and cooperatives promote small scale technologies for sustainable agriculture. Small farmers benefit from extension services. | <ul style="list-style-type: none"> • Large agrarian companies hire small farmers, which transfer the knowledge to the local community. |
| <ul style="list-style-type: none"> • Booms in both off- and on-shore gas exploitation | <ul style="list-style-type: none"> • Local energy production systems are important; wind energy becomes important. | <ul style="list-style-type: none"> • Increases in both off- and on-shore gas exploitation but not as fast as in Scenario A. |
| <ul style="list-style-type: none"> • Improved existing paved road infrastructure (rural dirt roads are not improved). Schools and hospitals do not improve importantly | <ul style="list-style-type: none"> • Improved small, local roads, and other infrastructures needed: schools, hospitals and energy providers. | <ul style="list-style-type: none"> • Improved existing Paved? road infrastructure (rural dirt roads are not improved). Schools, hospitals and energy are built by big investments |
| <ul style="list-style-type: none"> • Communication and internet technology advancements slowly expands in rural areas to reach more communities. | <ul style="list-style-type: none"> • Government and NGOs improve rural access to the Internet at accessible costs. | <ul style="list-style-type: none"> • Access to the internet improved in some rural communities. |

Environmental aspects

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • Biodiversity conservation is relegated as a side-issue. The implementation of conservation policies is weak. | <ul style="list-style-type: none"> • Biodiversity conservation is given national and regional prominence and the implementation of conservation policies is strong. | <ul style="list-style-type: none"> • Biodiversity conservation receives attention, mainly led by international bodies. |
|--|--|---|

<ul style="list-style-type: none"> • Climate change adaptation and mitigation strategies are more reactive than proactive. Only big investments adapt to climate change. 	<ul style="list-style-type: none"> • Climate change mitigation and adaptation are taken seriously with NGO's support. 	<p>Climate change adaptation strategies are strategically applied in small projects rather than in large programmes. The level of police implementation is weak in many districts.</p>
<ul style="list-style-type: none"> • Few protected areas mostly dedicated to ecotourism. 	<ul style="list-style-type: none"> • Several wildlife protected areas, some used for community-eco-tourism 	<ul style="list-style-type: none"> • Increase of protected areas
<ul style="list-style-type: none"> • The bureaucracy for land use takes to the abandonment of forest plantations. Informal or illegal native forest degradation continues. 	<ul style="list-style-type: none"> • Sustainable forest management is promoted. 	<ul style="list-style-type: none"> • Native forest cover declines as forest plantations increase. Sustainable forest management is also promoted in some areas.
<ul style="list-style-type: none"> • Charcoal production has degraded large areas. 	<ul style="list-style-type: none"> • Land use change is forced by an increase in agricultural area through small farming initiatives; this change is partly to conservation agriculture and agroforestry 	<ul style="list-style-type: none"> • Charcoal has affected large areas of woodland and this exploitation has increased in the last 20 years

Economic aspects

<ul style="list-style-type: none"> • Industrial growth has seen massive investment. 	<ul style="list-style-type: none"> • Industrial growth increases slightly, mainly small scale. 	<ul style="list-style-type: none"> • Industrial development has seen massive investment.
<ul style="list-style-type: none"> • The government promotes large private agricultural schemes. 	<ul style="list-style-type: none"> • The government promotes local agricultural projects. 	<ul style="list-style-type: none"> • It is advanced through large agro-companies; but, public and NGO promote sustainable resource management in local communities.
<ul style="list-style-type: none"> • The ratio overseas / local investment is heavily biased towards foreign finance 	<ul style="list-style-type: none"> • Overseas private investment is encouraged but limited to companies that offer deals to communities in exchange for natural resources. An increase in tax revenues allows more access to credit by small farmers, more diversified job opportunities with most of the families 	<ul style="list-style-type: none"> • The ratio overseas investment / local ownership is heavily biased towards foreign financing; however, civil society organisations have managed to curtail much of this growth in some areas

improving their livelihoods and wellbeing.

- | | | |
|---|--|---|
| <ul style="list-style-type: none"> • Low taxes applied to foreign investors due to tax exemptions promoted to attract investments. | <ul style="list-style-type: none"> • With the promotion of small medium enterprises, the increase of revenues is noticeable. | <ul style="list-style-type: none"> • Significant increase in the tax base. |
| <ul style="list-style-type: none"> • Small credits remain difficult to obtain for small farmers | <ul style="list-style-type: none"> • At a local level, credit schemes are popular with farmers to employ sustainable farming technologies | <ul style="list-style-type: none"> • There is a risk of inefficiency and effectiveness of credit resources. |
| <ul style="list-style-type: none"> • Employment opportunities revolve around the large private-sector investment. | <ul style="list-style-type: none"> • Employment opportunities appear in new local rural projects | <ul style="list-style-type: none"> • Employment contracts are heavily biased towards the private sector. Some local farming and forestry initiatives manage to create employment |
| <ul style="list-style-type: none"> • Tourism income has increased | <ul style="list-style-type: none"> • Tourism income is a major component of Mozambique's GDP | <ul style="list-style-type: none"> • Tourism income has become a major component of Mozambique's GDP |
| <ul style="list-style-type: none"> • Energy demand increases, especially in cities and industrial areas. | <ul style="list-style-type: none"> • Charcoal demand is lower than in scenarios A and C | <ul style="list-style-type: none"> • The demand for energy increases in the cities and rural areas but the supply is met more and more from renewable energy sources |
| <ul style="list-style-type: none"> • Emergence of a urban middle class, but still there is a very large percentage of poor families, especially in rural areas | <ul style="list-style-type: none"> • Livelihoods improve markedly in rural areas | <ul style="list-style-type: none"> • There is a balance between scenarios A and B: |

Policy and politics

- | | | |
|---|--|--|
| <ul style="list-style-type: none"> • Democratic freedoms are somewhat reduced. | <ul style="list-style-type: none"> • Healthier democracy and a more inclusive government | <ul style="list-style-type: none"> • Democracy is improved but will not be stable because of the lack of transparency on the management of local development funds. |
| <ul style="list-style-type: none"> • There are free (and private) media. | <ul style="list-style-type: none"> • The role of the media is relatively free even though dominant state ownership. | <ul style="list-style-type: none"> • The role of the media is relatively free even though dominant state ownership. |

- | | | |
|---|---|---|
| <ul style="list-style-type: none"> • Implementation of social and environmental policies do not improve. | <ul style="list-style-type: none"> • Policy implementation is well funded and string throughout the country. | <ul style="list-style-type: none"> • Social and environmental policy implementation improves (not as much as in scenario B). |
| <ul style="list-style-type: none"> • Mozambique's relation with its neighboring countries is improved through greater trading partnerships | <ul style="list-style-type: none"> • Mozambique provides a model for other African countries | <ul style="list-style-type: none"> • Mozambique has increased its status in global politics due to the balance it is trying to achieve with private investment and natural resource management |
| <ul style="list-style-type: none"> • The country benefits from a peaceful period. | <ul style="list-style-type: none"> • The country benefits from a peaceful period. | <ul style="list-style-type: none"> • The country benefits from a peaceful period. |

2. Full description of the storylines of each scenario.

2.1. Scenario A: Large private investments scenario

Societal aspects

Population will continue to increase from the current 28 million inhabitants to 44 million in 2035.

Migration from rural to urban areas: There is large urbanization at the expense of rural migration although rural areas grow in population as well. This pattern is because of low opportunities in rural areas and big investments near urban areas.

Social services (as energy, water, schools, extension services, hospitals, health care clinics, etc.) declines as the government becomes more libertarian. A poorly funded health service struggles to meet demand. Private healthcare increases in urban areas. Resources to education and training are also low, and general education does not improve significantly. Environmental education is not seen as a priority for the state. Several projects do not yield the expected results, i.e. the “fund for district development” (7 billion project), SUSTENTA project in Cabo Delgado and Zambezia, or PROMER project in Cabo Delgado, Niassa, Nampula, and Zambezia provinces. **National civil society organizations** have decreasing influence, although their need is greater than ever. In this scenario, there are numerous social conflicts, as a reaction to large investments, which sees a rise in smaller local community organizations. Nevertheless, the reaction from the government, the strength of the big companies and the lack of organization between the small local organizations decrease the influence of community organizations.

Empowerment of citizens is weak due to a lack of strong social services and limited access to new communication technologies.

Livelihoods improve in those rural families that benefit from large investments (in farming, mining, or industrial). Yet some families are impoverished at the same time because families are forced to move from their lands. Most rural families do not improve their livelihoods because of scarce education, training and extension services. The risk of vulnerability and social exclusion increases, especially around cities.

Land management and security: the implementation of land law still has to be consolidated, community with fragile capacity to protect their rights, eventual exacerbation of conflicts and therefore risks of community displacements in favor of the private sector. Land zoning policies have become less powerful due to the rigidness of their prescriptions which often go against investor opportunities (e.g., preventing agricultural development in forested landscapes). This land zoning policies are linked to access to power and lobbying by large corporations on government departments (often behind closed doors). Land use plans need yet to be consolidated and the dissemination and implementation of regulation is in a nascent phase. Risk of overlapping and distortion on the management of vocational use of resources.

Gender: Gender oriented policies have low impact, and economic activities usually favour men, who are more easily contracted by large investments, leaving women in a weaker situation than today.

Culture: The influence of big and international companies brings new values: the local culture in urban areas is not preserved in the young generations.

Training: The government does not push these mega projects to train their workers, so the local population is not hired, and the projects come with their workers (e.g. from South Africa or China).

Technology aspects

Agricultural development expands significantly with the government promoting large private investment schemes. The main goal is to increase yields and the efficiency of production using technology and machinery which ends up being adopted by large agri-companies and contractors but evades small farming initiatives due to the high costs these imply. Intensive and high-input farming is followed in those large projects. Some technology improvements are applied to facilitate international exportation of crops. There are no numerous transformation industries and agricultural products are exported without processing.

The energy sector explodes with booms in both off- and on-shore gas exploitation, primarily for export (Liquefied natural gas, LNG); LNG becomes a major global player in the industry, which has significant benefits for GDP.

Investment in road infrastructure: One consequence of gas exploitation is the need to improve the existing paved road infrastructure; rural dirt roads are not improved unless these connect to important agri/forest/energy estates. Other much needed **infrastructures** like schools and hospitals do not increase at high speed; these are sometimes linked to big investments.

Communication and internet technology advancements still slowly expand in rural areas, but the increase in these technologies is high where there is significant overseas investment. Nevertheless, although big plantations promote internet connection, it is too expensive for small farmers. Literacy continues to be a barrier for using the internet and other devices of information and communication technologies.

Environmental aspects

Biodiversity conservation is relegated to a side-issue for the government despite lobbying from NGOs; in some areas, eco-tourism provides a significant income for private corporations. In general, the implementation of conservation policies is weak. In essence: large companies (all those not working in eco-tourism) have the approval from the central government, but neither of them is really worried about biodiversity conservation because these are not directly affected by biodiversity loss. Furthermore, the government has a low capacity to control it.

Climate change adaptation and mitigation strategies are more reactive than proactive. Adaptation is effectively achieved only by the large agri-businesses, that invest in irrigation systems. Natural hazards, including floods, have increased in frequency and affect rural resource management, regardless of scale. Soil degradation has increased as a consequence. Natural hazards produce great losses to the affected local communities and infrastructures, which counteracts the local development efforts.

Protection to Wildlife: There are still a few protected forest reserves; these reserves are mainly managed for eco-tourism.

Forest management: The bureaucracy for land use takes to the abandonment of forest plantations. Informal or illegal native forest degradation continues.

The main land use changes: are produced by large farms' projects. Charcoal production has degraded large areas of woodlands and this exploitation has increased in the last 20 years. Fire management is prevalent in some areas.

Air and water pollution has increased since 2015, mainly due to more intensive agri-practices.

Economic aspects

Industrial growth has seen heavy investment, not only from the state but led by private investors. But there are only a limited number of industries and the main sectors are gas, mineral mining and large-scale agriculture. The ratio between overseas investment and local ownership is heavily biased towards foreign financing.

By increasing **long term land leases and concessions**, the state has allowed many overseas investors to enter the Mozambican economy and play a major role in GDP. In this way, the government promotes large private agricultural and forestry schemes.

The state income increases due to land concessions and **taxation** of foreign investment; even the taxes applied to the international investors are low due to tax exemptions promoted to attract investments. This money does not always trickle down to the main societal needs and a large percentage goes towards infrastructure development.

Credit schemes: small credits remain difficult to obtain for small farmers, potentially risk of social exclusion and lack of maximization of credit resources for integrated development.

Employment opportunities revolve around the large private-sector investment. However, new economic services arise, for example, a burgeoning Information Technology (IT) sector meets the demand of other industrial development needs, as well as other infrastructure improvements.

Tourism income has increased due to improved marketing of Mozambique's natural wealth overseas (and also as a consequence of greater foreign business involvement).

Energy demand increases, especially in industrial areas and in cities, due to the great migration from rural areas to urban areas, because of the small economic opportunities in rural areas.

Re-distribution of wealth has become a critical issue. There is a strong emergence of an urban middle class, but there is still a very large percentage of poor, especially in rural areas.

Therefore, despite increasing GDP, the Gini index has reduced and the disparity between rich (now even richer) and poor (as poor as today) has increased. Access to credits for farmers has increased but it is locked into 'green revolution' seed/fertiliser/tech packages.

Policy and politics

Democratic freedoms are somewhat reduced due to the growing influence of the private sector on government decision-making.

Despite the slight decline in a pure democracy, there are free (and private) **media** that fully utilizes modern technology to disseminate information. This new media and technologies are however not effective at enabling the self-organization of citizens because of poor access in rural areas. Community groups occur in some urban areas, but are heavily controlled by the government.

Social and environmental policy implementation does not improve because of state funding is targeted mainly at big infrastructure projects or is lost to corruption and inefficient bureaucracy; this results in a proportional reduction in the budget for public services. The implementation of social policies will be a challenge due to the number of private companies involved and weak government apparatus to enforce laws.

Mozambique's relation with its neighboring countries is improved through greater trading partnerships; furthermore, several global countries see Mozambique as important partner for trade, including China, many EU countries, Brazil, and India.

Scenario B: Small holder promotion

Societal aspects

The population of Mozambique has increased from the current 25.7 million habitants to 38 million in 2035.

Migration from rural to urban areas: The urban/rural population ratio remains quite stable due to many successful rural development programmes.

State run social services (health and education services, energy, water, schools, extension services, hospitals, health care clinics, etc.) are empowered and effective throughout the country but often run in tandem with NGO assistance and foreign aid. Societal dependence on the state is quite high, largely because the state is often a sole provider of health, welfare and education services and providers. As an example, the “Fund for district development” (7 billion Project) is effective because the policies and investments incentives at both small and medium scales are inclusive to the rural sector.

Civil society organizations are effective at enabling communities to have a voice in local and national democracy but these also work to provide awareness of sustainable livelihoods and environmental management. This is very important in the successful functioning of social services.

Empowerment of citizens is widespread due to the improvement of social services (formal education, sanitation, etc.), and the access to new communication technologies that prompts the exchange of information and increases the influence of successful initiatives.

Livelihoods improve markedly in rural areas, especially where extension services, rural local development projects and other social services have been implemented and improved. Rural population has received better formal education and training, and this new knowledge has improved food security in rural communities: productivity has increased and farming is more resilient to crisis.

Land management and security: Knowledge about land rights and instruments for its implementation will be improved, there will be transparency on the management of land use, and therefore a better dialogue among stakeholders and sustainable land use management. Decentralization and institutional empowerment are reinforced. Instruments to set up land use planning are developed and land planning training is well set up.

Gender: the political environment encourages the entrepreneurship for women, men and youth, which improves the livelihood and influence of women in society.

Culture: The success of the rural population acts as a counterforce to the influence of big and international companies, which allows some local culture to be preserved. Some new tourist initiatives help to preserve some local culture, like traditional artistic and craft products.

Training: The government achieves to secure the education of local employees as a way to provide a trained workforce to the new investments coming into the country, and the local population is hired in most by most of them.

Technology aspects

Agricultural development is advanced, but not in the same manner as Scenario A; rather, it has promoted, through technology transfer, extension services and the work of associations and cooperatives, small scale technologies for sustainable resource management (conservation agriculture, agroforestry, etc.). The government promotes local agricultural projects. Environmental awareness also increases, which contributes to reach a more sustainable agriculture. Associations and cooperatives achieve building new irrigation schemes.

Similarly, technology has been widely used to advance local renewable **energy** production systems such as solar and wind, that become very important energy sources in rural areas. Gas exploitation increases following a slow path.

The most necessary **infrastructures** (schools, hospitals, roads, and energy infrastructures) improve on a good pace. **Investment in road infrastructure** is quite high and it improves small, local roads rather than increasing or improving large 'highways'. Local small companies are largely hired for this work, like it is already occurring in Zambezia, with some artisans making pavements (in 2035 they are producing as a family sector).

Government and NGOs put an effort on improving local and rural access to quick and cheap **communication and the Internet**, which has also enabled some communities to branch out into tech industry and home working.

Environmental aspects

Biodiversity conservation is given national and regional prominence, not only for the ecosystem services that can be delivered, but also for intrinsic value reasons, therefore the implementation of conservation policies is strong. The awareness among this issue at the international level increases the demand of certification, which in 20 years ignites the interest on biodiversity conservation and sustainable use of natural resources. This is especially the case for small companies that usually acquire their license through the district and province, who are more concerned by the environmental consequences of economic activity. Civil society concerned with the negative environmental impacts that local communities suffer like lack of water, fertile soil and other natural resources), also contribute importantly to biodiversity conservation.

Climate change mitigation is taken seriously by the government with NGOs support, through sustainable agricultural techniques and by maintaining forest cover. Likewise, **adaptation** to droughts and floods is a major component of regional planning and management: there is an improvement in the capacity to implement, in awareness raising, in education and in investment capacity. Vegetation cover is kept high in flood-prone zones and efficient irrigation systems are commonly used.

Protection to Wildlife: There are more areas of protected wildlife, and some are used for community-controlled eco-tourism. Previous experiences with corrupt payment for ecosystem services schemes in this field are low due to a better trained and better funded police/ranger force.

Sustainable forest management is given top priority for extension training and in many areas, forest reserves are relatively intact and biodiversity rich. Community ownership or stewardship is common.

Land use change is forced by an increase of agricultural area through small scale farming initiatives. This change is partly to conservation agriculture and agroforestry. Soil management is taught throughout Mozambique as a critical part of sustainable land management. Monitoring, supervising and punishing are implemented, which helps to reduce the occurrence of law infractions regarding environmental management.

Economic aspects

Industrial growth increases slightly by the need to focus on a bottom-up community approach; some large-scale industries grow, in particular, the off-shore gas plants. Meanwhile mining is controlled and managed to ensure it does not expand into precious natural habitats. Overseas private investment is encouraged but it is also limited to companies that offer deals to communities in exchange for natural resources - there is no one-sided exploitation.

Long term leases or concessions of Mozambique's resources are unheard of; the left-leaning political history of the country still pervades society and government thinking. This scenario leads to an explosion of small and medium enterprises that will open the door for governments at the regional level to establish commercial relationships with other industries because of the need to export produce.

High **taxes** on international companies are part of the reason for a small increase in large foreign investments; and at the same time, it is the reason for an improvement in state funding. The improvement of policy implementation improves the functioning of taxes in the small or informal sectors, which slightly contributes to increase the state budget.

At the local level, **credit schemes** are popular with farmers to employ sustainable farming technologies (e.g., irrigation, agroforestry). The amount and diversification of credit schemes are improved, and the quality of service and technical assistance is diversified and maximized.

Rural employment is not just concerned with food and timber production, but also with the improvement in cheap internet access as well. This, as well as a cohesive education system has enabled small tech businesses to grow throughout the country.

Tourism income is a major component of Mozambique's GDP with several areas of the country popular with foreign tourists due to its natural beauty. Eco-tourism is the most popular form of tourism. Large ecotourism projects are promoted by the state.

Energy demands remain high despite a huge government effort in the promotion of renewable energies; however, this has curbed the worst excesses from charcoal production. Cheap, domestic solar power supplies (aided by state grants) have revolutionised rural energy supply. Charcoal demand is lower than in scenarios A and C because the urban population does not grow as fast and because of the spread of renewable energies.

Re-distribution of wealth: most rural communities improve their livelihoods: food sovereignty is achieved due to the focus of extension services on sustainable and small scale agriculture production systems.

Policy and politics

Democracy and driving Forces: Two different forces have led to a healthier democracy and a more inclusive government.

- **The Role of Communication Technology:** The first driving force is the proliferation of internet-based technologies, which ensures that free speech is guaranteed without the threat of violence, ensures a quicker organization of protests and facilitates the self-organization of civil organizations.
- **Government Commitment:** The second driver is the real commitment of the government to improve democracy following two lines: an excellent effort to improve general education and the practice of a more open and transparent governance. Both drivers produce a positive feedback to each other. In essence, a more open democracy improves community empowerment, and community empowerment improves democracy: the empowered and self-organized citizens push the government heavily towards transparency and local-oriented policies. The increase in ICT, even in rural areas, increases the voice of local organizations and pushes the government to increase the public involvement in rural development and an improvement of public services.

This scenario creates a medium-class interested to participate in the decision-making process and make a difference for local development.

Therefore, **democracy** is healthy in Mozambique; elections are held mostly without the fear of intimidation or reprisals and this pattern is the same whether at local or national scale. Policy

implementation is well funded and spread throughout the country; levels of training and checks on corruption ensure the police is respected and effective.

Finally, **the role of the media** is relatively free despite that much of it being state owned.

As a result of the previously explained situation **social and environmental policy implementation** is successful and most rural citizens benefit from a highly improved and effective education, health and (extension) training services.

Mozambique's relation with its neighboring countries: Mozambique provides a model for other African countries seeking foreign investment without jeopardizing their natural resources. Mozambique's approach to sustainable resource management and protection of local communities gathers a lot of support from environmental NGOs and many countries around the world. Mozambique becomes a model on combining small and medium-sized enterprises in a sustainable way.

2.2. Scenario C: Intermediate scenario

Societal aspects

Population will continue to increase from the current 25.7 million habitants to 40 million in 2035.

Migration from rural to urban areas: There is large urbanisation at the expense of rural migration although rural areas grow in population as well.

The state tries to run **extension, health and education services** (and other social services like energy, water, etc.), but only some districts manage to translate this budget effort into successful results. NGO assistance and foreign aid are still of great importance.

Some **civil society organisations** are effective at enabling communities to have a voice in local and national democracy. However large international companies are also very effective at implementing their projects which results in negative consequences for affected local populations.

Empowerment of citizens generally increases, although there are big differences between different districts and provinces.

Livelihoods: Some urban families improve their well-being, but a big number remains very poor and some rural communities improve their situation. Food security remains a big concern for many rural families.

Land management and security: there is an environment where institutions are unable to reinforce the implementation of land law, land disputes are exacerbated, and therefore the most vulnerable are likely most exposed to the risk of displacement. Land use policies are well designed but not sufficiently absorbed by stakeholders. The institutional capacity to reinforce needs is yet to be consolidated. Then, there is a risk of both overlapping and disputes between priorities of use and this can lead to an unsustainable use of land.

Gender: the big companies favour jobs for men, weakening women. Nevertheless, the success of some social services is especially beneficial for women, which in some districts can use an improved entrepreneur environment to improve their livelihoods.

Culture: In some districts the success of the rural population acts as a counterforce to the increasing influence of big international companies, so that local culture is partially preserved. New tourist initiatives help to preserve some local culture, like traditional artistic and craft products, but also to bring new cultural values to the tourists, what also has a big influence in young people.

Training: The government achieves to secure the education of local employees to provide a workforce to the new investments coming into the country. An inclusive and integrated training programme is achieved hiring the local population.

Technology aspects

Agricultural development is advanced through technology, agronomy, and machinery and large agro-companies and contractors are flourishing; however, through technology transfer (from farmers working in the large plantations) and public and NGO promoted extension services, new agrarian technologies reach many local communities.

The energy sector increases in both off- and on-shore gas exploitation, primarily for export (LNG) but not as fast as in Scenario A. Nevertheless, LNG also becomes a major global player in the industry which has benefits for GDP. There is an increase as well in the excitation of coal. One consequence of this gas exploitation is the need to improve the existing paved **road infrastructure**, although rural dirt roads are not greatly improved. Other needed **infrastructure**

(schools, hospitals, and energy infrastructures) improve, in some cases linked to these large investments.

Local access to quick and cheap **communication and the internet** has improved, thus enabling some rural communities to expand their business opportunities.

Environmental aspects

Biodiversity conservation receives attention, mainly led by international bodies, in part through the international REDD+ programme (Reducing Emissions from Deforestation and Forest Degradation) and other types of payment for ecosystem services. Eco-tourism and hunting are also widely promoted to conserve good ecological conditions in large parts of Mozambique.

Climate change adaptation strategies are strategically applied to small projects rather than in large programs (e.g. limiting small farming in high flood-prone zones but not for large farming projects). Natural hazards, including floods, have increased in frequency and affect rural resource management regardless of scale. Soil degradation has increased as a consequence. The level of police implementation is weak in many districts, although there is an improvement in a) the capacity to implement, b) in awareness raising, c) in education and d) in investment capacity.

Protection to Wildlife: The number of protected forest reserves increases slightly, most of them mainly managed for eco-tourism. There are some experiences of corrupt payment for ecosystem services schemes.

Sustainable **forest management** is promoted through extension training and, in some areas, forest reserves are relatively intact and biodiversity rich. Community ownership or stewardship is not common but widespread in some districts within the country. Native forest cover declines as forest plantations increase.

Land use changes: Native forest cover declines as plantation species increase; management is geared towards silviculture rather than biodiversity or other ecosystem service delivery. Fire management is prevalent in some areas, particularly where there are large external investments. Farmland increases both from small farmers and from large companies' expansions.

Economic aspects

Industrial development has seen some heavy investment, not only from the state but also from private funding. However, a limited number of industries exist with the main focus on gas, mineral mining, and large-scale agriculture.

The ratio between overseas investment and local ownership is biased towards foreign financing and to increasing **long-term leases**. This has allowed many overseas investors to enter the Mozambican economy (which contributes significantly to GDP). However, civil society organizations have managed to curtail much of this growth in some areas in order to minimize the scale of some of the biggest projects. Public bodies and NGOs promote sustainable resource management in the local communities.

Some of the money raised from privatization and **taxation** of foreign investment (not as low as in Scenario A) trickles down to benefit society through education, welfare and health provision although a large percentage goes as well towards infrastructure development.

Credit schemes: the number of services are improved, there is a potential bias towards the large private sector, and marginalized asset for grassroots' farmers. There is a risk of inefficiency and lack of effectiveness of the credit schemes.

Employment contracts are heavily biased towards private sector industries and the security of employment is fragile for many people. There are however some local farming and forestry initiatives that manage to create stable employment in rural sectors. In many districts access to

cheap internet, a good health and education system and better road infrastructure have enabled new SME businesses to grow.

Tourism is boosted due to an effective overseas marketing campaign and investment in decent tourism infrastructure. Tourism income has become a major component of Mozambique's GDP due to an increase in direct flights to Maputo from several the Middle East and European cities.

The demand for energy increases in the cities and rural areas, with the supply increasingly provided from renewable energy sources. A huge investment in off-shore wind and wave power generation provides a significant supply of renewable energy. Charcoal demand increases.

Re-distribution of wealth: there is a balance between scenarios A and B: the increase of government budget allows to fund better social services, which increases the wealth of lower income families.

Policy and politics

Democracy is improved in Mozambique; elections are held without too much fear of intimidation or reprisals. Private sector influence on government policy is significant, yet some corruption cases have become publicized and dealt with. The levels of training and checks on corruption do not ensure however that the police is respected and effective.

The role of the **media** is relatively free despite that much of the media is state owned. The proliferation of internet-based media, from blogging to news websites, ensures that free speech is guaranteed without threat of violence. New media and technologies allow the empowerment and self-organization of citizens, who push the government towards transparency and local-oriented policies. Nevertheless, the government controls and stops those protests, which only are successful in certain cases. There is still a lack of transparency, e.g., on the management of local development funds.

Social and environmental policy implementation improves (not as much as in scenario B) due to a gradual increase in civil organizations and protests, and access to the news, which is triggered by the new ICT technologies. Lack of funding at the state level is poor in some areas, and corruption and incompetence are still prevalent in many districts.

Mozambique's relation with its neighboring countries has increased its status in global politics due to the balance it is trying to achieve between private investment and natural resource management. Many European countries in particular support this approach although some countries like China lobby hard to be allowed to have greater access to Mozambique's natural resources.

Table S4. Land use changes associated with each land use category, applied to the Mabalane District (Gaza Province). It was completed by ACES team based on our knowledge.

Land use change attributes of the storylines – Mabalane district (Gaza Province).

Land cover			Scenario A	Scenario B	Scenario C	Main drivers of land use change
Forest	Native-non degraded	Mopane/Miombo	Decreases heavily	Decreases	Decreases slightly	Charcoal production Charcoal demand Charcoal licenses control Rural development Forest management Farmland extension
		Other woodland types	Decreases	Decreases slightly	Decreases slightly	Farmland extension Plantations grow Charcoal production
	Native - degraded	Mopane/Miombo	Increases heavily	Increases	Increases slightly	Charcoal production Charcoal demand Charcoal licences control Rural development Forest management Farmland extension
		Other woodland types	Increases	Increases slightly	Remains the same	Charcoal production Farmland extension Plantations grow
	Plantation		Increases	Increases	Increases	International or local/national driven forestry projects
Other Habitats	Wetland		Decreases	Decreases	Decreases	Farmland extension
	Grassland		Increases	Increases	Increases	International or local/national driven cattle/agroforestry projects
Agriculture	Large-scale Commercial Agriculture (commodity export)		Increases heavily	Increases	Increases slightly	International driven agricultural projects for exportation (soya, tobacco, sugar cane, cotton, cashew...) Private extension services
	Small-scale Commercial agriculture (domestic sales)		Increases slightly	Increases	Increases heavily	Local/national driven rural development projects Public extension services

Land use change attributes of the storylines – Mabalane district (Gaza Province).

	Subsistence agriculture	Increases	Increases	Increases	Lack of development interventions, population growth
Built environment	Urban infrastructure	Increases	Increases	Increases heavily	Rural development policies
	Metalled roads	Increases	Increases	Increases	Public/private investment in infrastructures
	Dirt roads	Increases	Increases	Increases	Public/private investment in infrastructures
	Rail	Remains the same	Remains the same	Increases	Public/private investment in infrastructures