Futures of inland aquatic agricultural systems and implications for fish agri-food systems in southern Africa

RESEARCH PROGRAM ON
Aquatic Agricultural Systems

FUTURES OF INLAND AQUATIC AGRICULTURAL SYSTEMS AND IMPLICATIONS FOR FISH AGRI-FOOD SYSTEMS IN SOUTHERN AFRICA

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LIST OF ACRONYMS

AAS	CGIAR Research Program on Aquatic Agricultural Systems
AU-NEPAD	African Union's New Partnership for Africa's Development
CAADP	Comprehensive Africa Agriculture Development Program
CIRAD	French Agricultural Research Centre for International Development
FARA	Forum for Agricultural Research in Africa
GFAR	Global Forum on Agricultural Research
S3A	Science Agenda for Africa
STEEP	social, technical, economic, environmental, policy and political

LIST OF DEFINITIONS

Agri-food system	A set of activities that combine to produce and distribute agri-food products to meet human food and nutrition needs in a particular society.
Aquatic agricultural systems	Diverse production and livelihood systems where families cultivate a range of crops, raise livestock, farm or catch fish, gather fruits and other tree crops, and harness natural resources such as timber, reeds and wildlife. Aquatic agricultural systems occur along freshwater floodplains, coastal deltas and inshore marine waters, and are characterized by dependence on seasonal changes in productivity, driven by seasonable variation in rainfall, river flow, and/or coastal and marine processes.
Complex systems	Systems that are made up of multiple interacting components exhibiting emergent macro-behavior and interacting dynamically with their wider contexts.
Drivers, driving forces	Factors causing change, affecting or shaping the future.
Expert	A person who has a special skill, knowledge, insight or ability in a particular domain based on research, experience, judgment or occupation.
Forecast, forecasting	A statement that something is going to happen in the future, often based on current knowledge and trends. Forecasting is the process of making a forecast.
Foresight	A systematic, participatory and multidisciplinary approach to exploring mid- to long-term futures and drivers of change.
Plausible	Judged to be reasonable because of its underlying assumptions, internal consistency and logical connection to reality.
Proactive	Oriented towards acting in advance of a future situation, averting undesirable futures and working towards the realization of desirable futures.
Scenario	A description of how the future may unfold according to an explicit, coherent and internally consistent set of assumptions about key relationships and driving forces.
System	A set of interconnected elements that is coherently organized in a pattern or structure.

INTRODUCTION

The CGIAR Research Program on Aquatic Agricultural Systems (AAS) is collaborating with partners to develop and implement a foresight-based engagement with diverse stakeholders linked to aquatic agricultural systems. The program's aim is to understand the implications of current drivers of change for fish agri-food systems, and consequently food and nutrition security, in Africa, Asia and the Pacific. Partners include the Global Forum on Agricultural Research (GFAR), the Forum for Agricultural Research in Africa (FARA) and the African Union's New Partnership for Africa's Development (AU-NEPAD).

A key part of the program was a participatory scenario-building workshop held in July 2015 under the theme of "futures of aquatic agricultural systems and implications for fish agri-food systems in southern Africa." The objectives for the workshop were (i) to engage local stakeholders in exploring plausible futures of aquatic agricultural systems, and (ii) to broker and catalyze collaborative plans of action based on the foresight analysis.

Foresight is a useful tool for recognizing that while the future cannot be predicted, it can be explored, and doing so can unveil new paths, options and unexpected effects of our decisions. Exploring the plausible futures of aquatic agricultural systems in southern Africa will help inform future research, development policies and practices, and investments to shape pathways towards desired futures in the region. In line with this, the participatory scenario-building workshop sought to investigate the following key questions:

- What are the plausible futures for aquatic agricultural systems in southern Africa?
- What are the implications of these plausible futures for the development and research investment, policy and practice needed to achieve Africa's goals and targets on hunger and nutrition as elaborated in the Malabo Declaration and the Sustainable Development Goals?
- How can decision-makers (including farmers) at all scales use these plausible futures to shift the research, development and policy agendas to influence desired development outcomes?

This report presents technical findings from the workshop. The second section explains global food and nutrition security challenges, and the third and fourth sections establish the importance of fish in addressing these challenges and the role of aquatic agricultural systems in supporting fish agri-food systems in southern Africa. The fifth section introduces foresight as an approach to exploring mid- to long-term drivers of change in these systems and building plausible future scenarios. The sixth section explains and discusses the detailed foresight methodology used in this study and the outputs produced during each of the steps. The final section provides detailed narratives of selected plausible scenarios of futures of aquatic agricultural systems in southern Africa.

GLOBAL FOOD AND NUTRITION SECURITY CHALLENGES

Over a billion people today live on less than US$1.25 per day, over 800 million are acutely or chronically undernourished, and around 2 billion are suffering from micronutrient deficiency or "hidden hunger." At the same time, the natural resources required for food production are under threat due to overexploitation of land, unsustainable water use and climate change (CGIAR 2015). Development is faced with a global challenge that is both complex and multifaceted. By 2050, food production systems will need to feed approximately 9 billion people in a way that provides sufficient nutrition to enable healthy lives.

Importantly, food supplies must be accessible to all, including resource-poor and vulnerable economic and social groups. At the same time, we need to ensure that the natural resource base is sustainably managed and not irreversibly depleted. Contemporary development challenges, including food and nutrition insecurity, poverty, and resilience, are of a global and complex nature. They need to be addressed through collaborative efforts that cut across sectors and involve diverse stakeholders. Acknowledgment of these global challenges is reflected in the post-2015 development agenda set out in the United Nations' Sustainable Development Goals 1, 2, 3 and 12 (Figure 1).

Investing in agri-food systems has significant potential to simultaneously contribute to multiple Sustainable Development Goals, particularly those that relate to reducing poverty, improving food and nutrition security for health, and improving natural resource systems and ecosystem services (CGIAR 2015). Many of today's food production systems are unsustainable, which makes future food security highly uncertain. However, the challenge of food security has social, economic and environmental dimensions. In order to increase the productivity of agriculture in a sustainable manner and increase the resilience of systems, the interactions between these three dimensions and the many layers of feedback between them need to be better understood (EC 2011).

The challenges of food and nutrition insecurity and poverty are most acute in South Asia and Africa. The number of food-insecure people in these two regions is projected to rise to about 660 million by 2025 from about 440 million in 2015. In 2015, Africa had the highest share of food-insecure population (28%) in the world, and the proportion is projected to rise to over 30% by 2025 (Rosen 2015). In response, a number of initiatives have been implemented to try to address the challenge. The Comprehensive Africa Agriculture Development Program (CAADP) was launched in 2003 and led by AU-NEPAD. This program provides a common policy framework for agricultural development in Africa and aims to reduce poverty, hunger and malnutrition by transforming subsistence agriculture into a sustainable farming business. African heads of state have committed to spend 10% of

Goal 1: End poverty in all its forms everywhere.

Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

Goal 3: Ensure healthy lives and promote wellbeing for all at all ages.

Goal 12 : Ensure sustainable consumption and production patterns.

Figure 1. Sustainable Development Goals on poverty, hunger and nutrition.

national budgets on agriculture annually and to make efforts to raise agricultural production by at least 6% a year. The Maputo 2003 Declaration, reinforced during the Malabo 2014 Summit, commits to ending hunger and halving poverty by 2025 through (i) inclusive agricultural growth and transformation; (ii) boosting intra-African trade in agricultural commodities and services; (iii) enhancing resilience of livelihoods and production systems to climate variability and other shocks; and (iv) mutual accountability to actions and results. In line with these continental goals, FARA contributes to achieving the CAADP goals through agriculture-led social and economic transformation by enhancing and deepening contributions of science, contributing to the Sustainable Development Goals. FARA's Science Agenda for Africa (S3A) envisions that "by 2030 Africa is food secure, a global scientific player, and the world's breadbasket."

However, the food and nutrition security equation is influenced by many forces of change (see Figure 2). Food availability in Africa is particularly challenged by traditional production methods and low productivity; inconsistent policies and weak institutions; low levels of trade among African countries; political instability and regional, ethnic conflicts; low public and private investment in agriculture; lack of purchasing power of smallholders to acquire and use modern technology; frequent disasters; land degradation; and climate change.

While food may be available, access is restricted by low incomes; high unemployment rates, particularly among youth and young adults; weak markets for staples and export commodities; poor infrastructure; weak regulation enforcement in intracountry and cross-border trade; and instability in markets, resulting in food price spikes. Further, food utilization is hampered by illiteracy and poverty, low technology use to address food quality and safety within countries and at borders, and policy failure in addressing dumping of low-quality food commodities (Asuming-Brempong 2015).

It is clear that addressing the challenge of food and nutrition security requires a multidisciplinary and systems perspective to be effective.

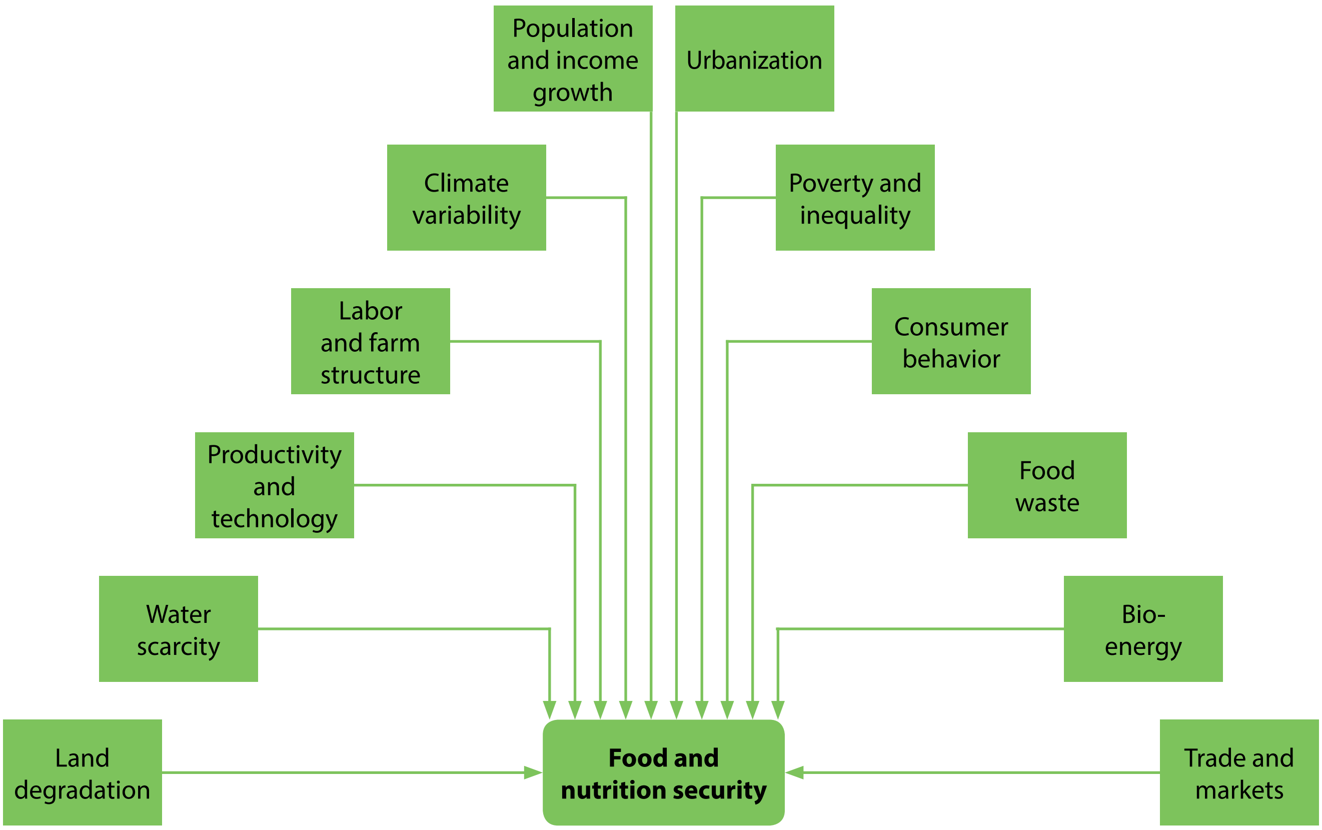


Figure 2. Forces of change influencing food and nutrition security (based on von Braun 2014).

THE IMPORTANCE OF FISH IN FOOD SYSTEMS

Fish and fishery products represent a valuable source of nutrients that are fundamental for diversified and healthy diets (FAO 2012). There is growing recognition of its nutritional and health-promoting qualities. Either produced through aquaculture or caught from wild marine or freshwater stocks, fish is a good source of protein and essential nutrients, which are particularly necessary during the first 1000 days of life (Longley et al. 2014). Research shows that increased consumption of fish and the addition of fish to the diets of low-income populations (including pregnant and breastfeeding mothers and young children) offers substantial opportunities for improving food security and nutrition (HLPE 2014). Beyond nutrition, fish is one of the most efficient converters of feed into high-quality food, and fish and fish-related products provide income and livelihoods for millions of people across the world (HLPE 2014; Béné et al. 2015).

Despite these benefits, limited attention has been given to date to fish as a key element in food security and nutrition strategies at national level and in wider development discussions. Debates have concentrated on questions of biological sustainability and on the economic efficiency of fisheries. This ignores the contribution of fish in reducing hunger and malnutrition, as well as supporting livelihoods.

The most notable omission of fish is from food and nutrition security strategies for reducing deficiency of micronutrients like vitamin A, iron and zinc, precisely where it could potentially have the largest impact (Allison et al. 2013). Micronutrient deficiencies are a major challenge for many countries in Africa. Vitamin A deficiency alone results in approximately 577,000 children dying each year, and another 40% of children under 5 suffering from stunting (UNICEF et al. 2015).

While Africa has the lowest consumption of animal foods per capita at around 28 kilograms annually, the proportion of fish in animal-source food consumption is high at 32.25% (Fishing for a Future 2013a). However, in some developing countries high levels of fish consumption and undernutrition coexist. In these cases, fish can become a culturally and practically appropriate means for addressing inadequate nutrition and dietary diversity, as it is a part of traditional diets (Fishing for a Future 2013b). Over the next decade, demand for fish in Africa is expected to grow by 25%–48% per person, and real fish prices are predicted to rise by 1% annually (Fishing for a Future 2013a). This affects the resource-poor, who are regularly the most undernourished. The potential contribution of fisheries and aquaculture to food security and nutrition, both now and in the future, is driven by interactions between environmental, development, policy and governance issues (HLPE 2014). This situation reinforces the need to use a multidisciplinary and systems approach to developing and implementing strategies that integrate fish into food and nutrition security interventions.

AQUATIC AGRICULTURAL SYSTEMS

Aquatic agricultural systems play an important role in the supply of fish from wild fisheries, as well as supporting aquaculture production. They are diverse production and livelihood systems where families cultivate a range of crops, raise livestock, farm or catch fish, gather fruits and other tree crops, and harness natural resources such as timber, reeds and wildlife. Aquatic agricultural systems occur along freshwater floodplains, coastal deltas, and inshore fresh and marine water bodies. These systems are characterized by dependence on seasonal changes in productivity, driven by seasonal variation in rainfall, river flow, and/or coastal and marine processes (AAS 2012). Fish and aquatic organisms dominate these production systems.

Approximately 83 million people in Africa depend on aquatic agricultural systems for their livelihoods. Of these, about 47 million live in poverty (Béné and Teoh 2015). Aquatic agricultural systems are important components of agri-food systems for rural and urban consumers and provide a source of dietary diversity and quality. The jobs created from the production and postharvest sectors, as well as formal and informal local, regional and international trade, are critical for livelihoods and incomes. However, global trends such as globalization, urbanization, increased climate variability, enhanced connectivity, changes in consumption, demographic changes, technology developments and rising inequalities (Bourgeois 2015) can all influence the future capacity of aquatic agricultural systems to support fish agri-food systems, address food and nutrition security, and enhance livelihoods.

Southern Africa and aquatic agricultural systems

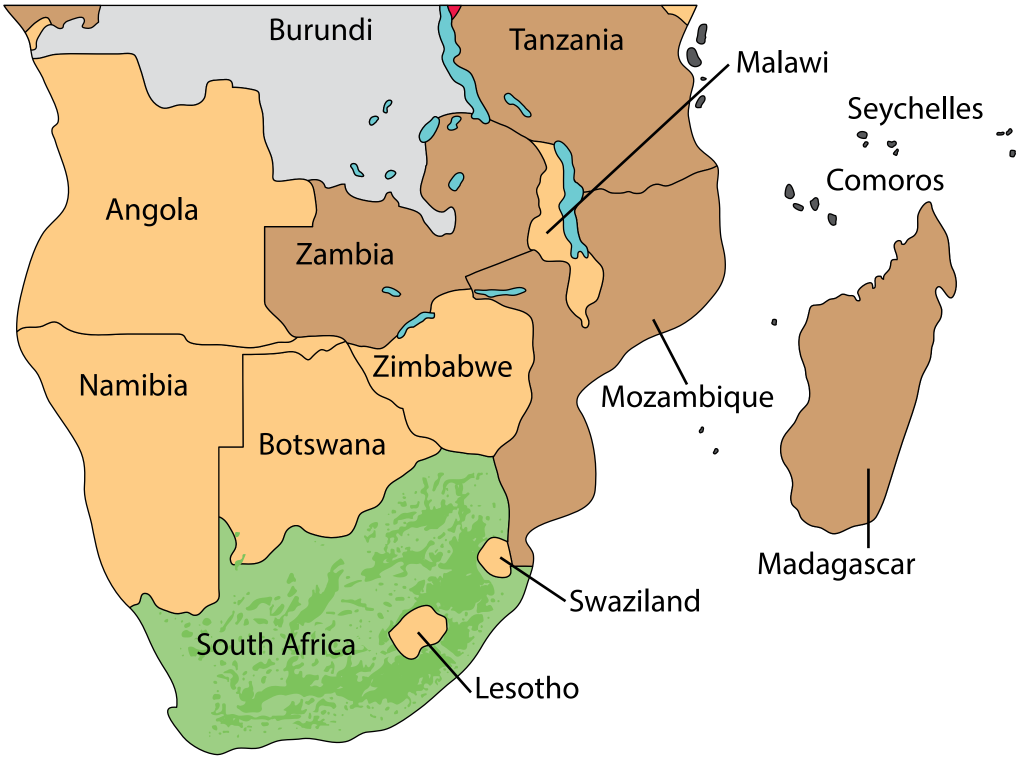
A large number of resource-poor people dependent on aquatic agricultural systems for their livelihoods in southern Africa are concentrated in Madagascar, Mozambique, Malawi and Zambia (Table 1). It is estimated that in Zambia and Malawi, 100% of the nation's total fish production comes from aquatic agricultural systems, while for Mozambique it is 69% and Madagascar 65% (L. Romijn, personal communication, 2015).

Paradoxically, these countries exhibit levels of hunger that are alarmingly high (Figure 3). They have a high to very high percentage of children under 5 who are stunted (Figure 4). Investing in aquatic agricultural systems to enhance the production of fish-based food products through increased productivity to reduce costs, along with strengthening equitable distribution systems to make them affordable and accessible to resource-poor consumers, can go a long way toward addressing these challenges in these countries and in the region.

Country	Estimated aquatic agricultural systems area (km²)	Aquatic agricultural systems-dependent population	Estimated number of aquatic agricultural systems-dependent poor (Multi-dimensional Poverty Index)	Estimated number of aquatic agricultural systems-dependent poor (HarvestChoice/ International Food Policy Research Institute)
Madagascar	40,956	2,948,329	2,101,146 (71%)	1,710,619 (58%)
Malawi	24,055	1,053,046	822,343 (78%)	662,822 (63%)
Mozambique	39,662	1,900,533	1,495,329 (79%)	1,036,717 (55%)
Zambia	25,900	911,229	691,518 (76%)	628,121 (69%)

(Source: Béné and Teoh 2015).

Table 1. Resource-poor people dependent on aquatic agricultural systems.



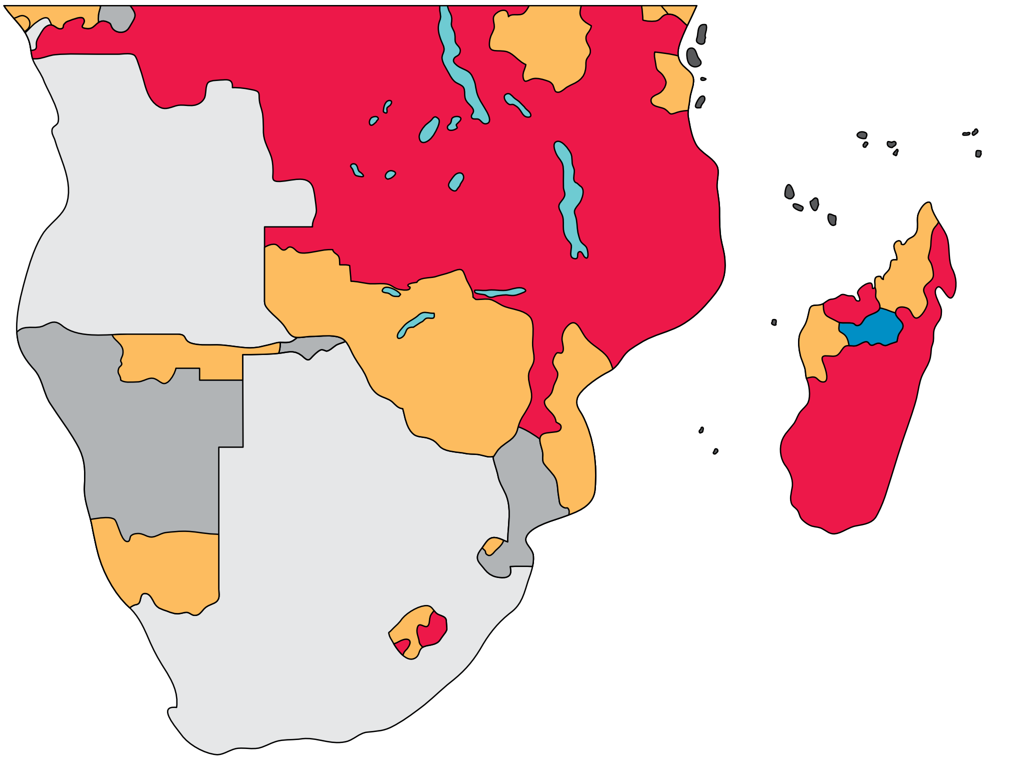
Severity: score

Low: ≤ 4.9 | Moderate: 5.0–9.9 | Serious: 10.0–19.9

Alarming: 20.0–29.9 | Extremely alarming: ≤ 30.0 | No data

(Source: HarvestChoice 2014).

Figure 3. 2013 Global Hunger Index scores.



Prevalence: percent

Low: ≤ 20 | Medium: 20–29 | High: 30–39

Very high: ≤ 40 | No data | Outside focus area

(Source: HarvestChoice 2014).

Figure 4. Nutrition and health among children under age 5—stunting.

FORESIGHT APPROACH

Foresight, as defined here, is a participatory and multidisciplinary approach to exploring drivers of change and mid- to long-term futures using a systems perspective. It encourages stakeholders and experts to explore future changes by qualitatively and quantitatively analyzing plausible future developments and challenges. The foresight process can foster a proactive attitude for communities faced with changes by unveiling uncertainties and using them as a means for action. When used in this way, foresight can support stakeholders to actively shape the future by influencing the development and implementation of strategies and actions today (GFAR 2014).

Looking forward in an attempt to plan for a better future is not a new concept, and the field of futures studies has evolved significantly over the past few decades. While earlier methods often focused on shorter-term forecasting and predictions (Slaughter 2002), the recent emphasis has been on the development of longer-term, anticipatory research and analysis techniques that can better deal with highly complex future challenges (Bourgeois 2012). Instead of looking at just one sector or a single dimension or trend, foresight can be applied from a systemic perspective using a multidimensional approach. Foresight does not deal only with trends but also with discontinuities and disruptions that break the trend.

The foresight approach has emerged as a collection of diverse qualitative and quantitative methods and tools that can be tailored to address relevant questions and meet different objectives. These include generating knowledge and interactions and/or catalyzing joint action to address anticipated challenges. Multistakeholder scenario building, as part of a foresight approach, can be particularly useful in identifying possible futures for uncertain interactions between human and natural systems. These can be subsequently used to inform planning for desired future pathways (Vervoort et al. 2013).

Approaches such as this, however, have only recently been applied to the complex problems around food systems and agriculture in the developing world (Chaudhury et al. 2013). Recent analysis of the foresight approach highlighted that it is significantly absent from agriculture planning in the world's least developed countries, particularly in sub-Saharan Africa (Bourgeois 2012). Holistic systems approaches that involve exploration of entire food systems—linking agricultural, environmental and human systems together—are needed to understand and meet the future food challenges of developing regions (Vervoort and Ericksen 2012).

The broader foresight approach remains dynamic, and advances in methodology are still required in order to achieve the "improved foresight" that is considered "essential for understanding future agricultural and rural development contexts and changes around the world and for driving the research and innovation required to meet the future food and nutrition security needs of the world's poor" (Bourgeois 2012, 4). Efforts by the global agricultural research-for-development community related to climate-smart agriculture and food systems are part of this move towards a strategic foresight approach for influencing the future (Bourgeois 2012).

WORKSHOP METHODOLOGY AND OUTPUTS

A multistakeholder participatory scenario-building workshop was conducted on 14–18 July 2015 in Lusaka, Zambia. The aim was to explore drivers of change in and plausible futures of aquatic agricultural systems, with a focus on Madagascar, Mozambique, Malawi and Zambia due to their high levels of poverty and food insecurity, as well as significant land area used for aquatic agricultural systems.

The workshop participants were selected to ensure diverse perspectives. The participants were asked to step out of the role of representing their organizations and focus on contributing their knowledge of the multiple facets of aquatic agricultural systems in their countries and region. Ensuring diversity in age, gender, ethnicity and power was an important consideration while selecting participants, as was their willingness to discuss and understand other opinions. Participants were invited both from the four countries of focus and to offer regional and continental perspectives. Among the 22 participants, the rich mix of expertise and experience consisted of African environmental history, fisheries and wildlife, agricultural economics, gender, public health, organizational management and change, innovation systems, modeling, climate change, water resources management, private sector aquaculture management, private sector technologies for agricultural information provision, markets and trade, women farmers, civil society organizations, and policies (Figure 5).

The Participatory Prospective Analysis (Bourgeois and Jésus 2004), which is currently implemented by GFAR, was used in the workshop. It uses scenario-building exercises based on the principles of inclusiveness, openness, using a bottom-up approach, detailed documentation, developing actionable scenarios, mutual learning and context-specificity. The method involved seven steps (Figure 6) that were worked through with participants over 5 days.

The summary of outputs from these steps is presented in the following subsections.

Defining the system

Process: Clarifying the question to be addressed through foresight is an important first step—defining the what, when, where and who. These dimensions define what is called a "system." It is the plausible transformations of this system that are explored in the foresight exercise.

Output: After discussion, the participants agreed that "fish and aquatic agricultural systems in southern Africa" was the appropriate system to focus upon. It was stressed that when we talk about systems, we are talking mainly about people that are dependent on and affected by systems, not just the biological, environmental or technical aspects. For reasons outlined above relating to the numbers of resource-poor people dependent on aquatic agricultural systems, it was agreed that the focus would be on Zambia, Mozambique, Malawi and Madagascar. It was also noted that the aquatic agricultural systems in these countries are diverse. As 10 years is the minimum number of years considered necessary for the foresight process, with 20 years ahead looking into the next generation, the timeframe of 15 years (to 2030) was considered a reasonable period in which policies and mandates could be influenced.

Identifying the forces of change

Process: A force of change is something that has the capacity to transform a system through its influence on outcomes. In this context, it is something that can influence the evolution of aquatic agricultural systems in southern Africa. Through brainstorming, participants were asked to identify all the forces that had a past, present and future influence on the evolution of aquatic agricultural systems. A definition for each force was then crafted and agreed upon by the participants. This process was important, as it necessitated the participants settling on a shared understanding of each force, enabling uniform interpretation. The identified forces of change were categorized into external and internal forces depending upon the capacity of actors in the system to

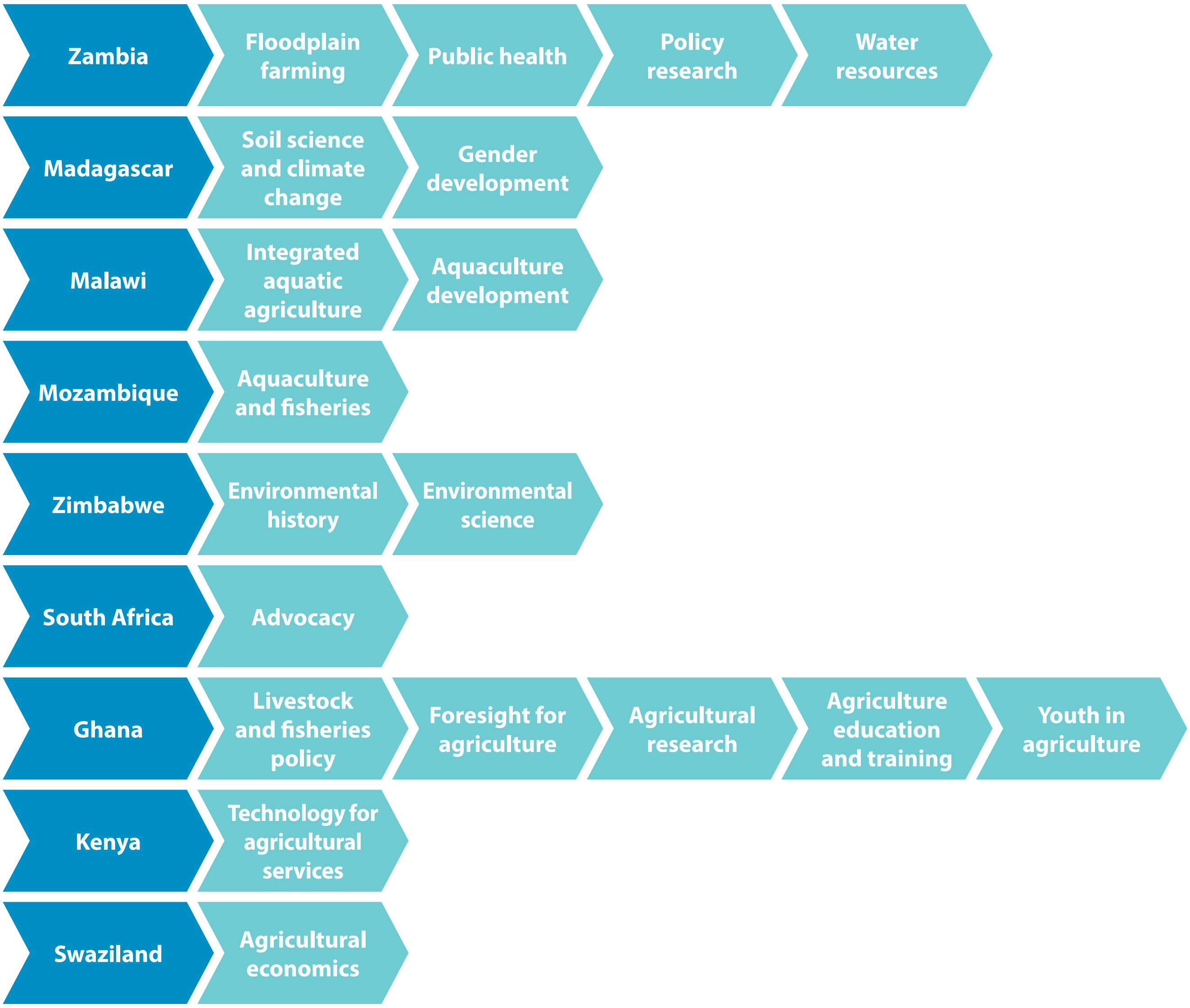


Figure 5. Countries and areas of expertise of workshop participants.

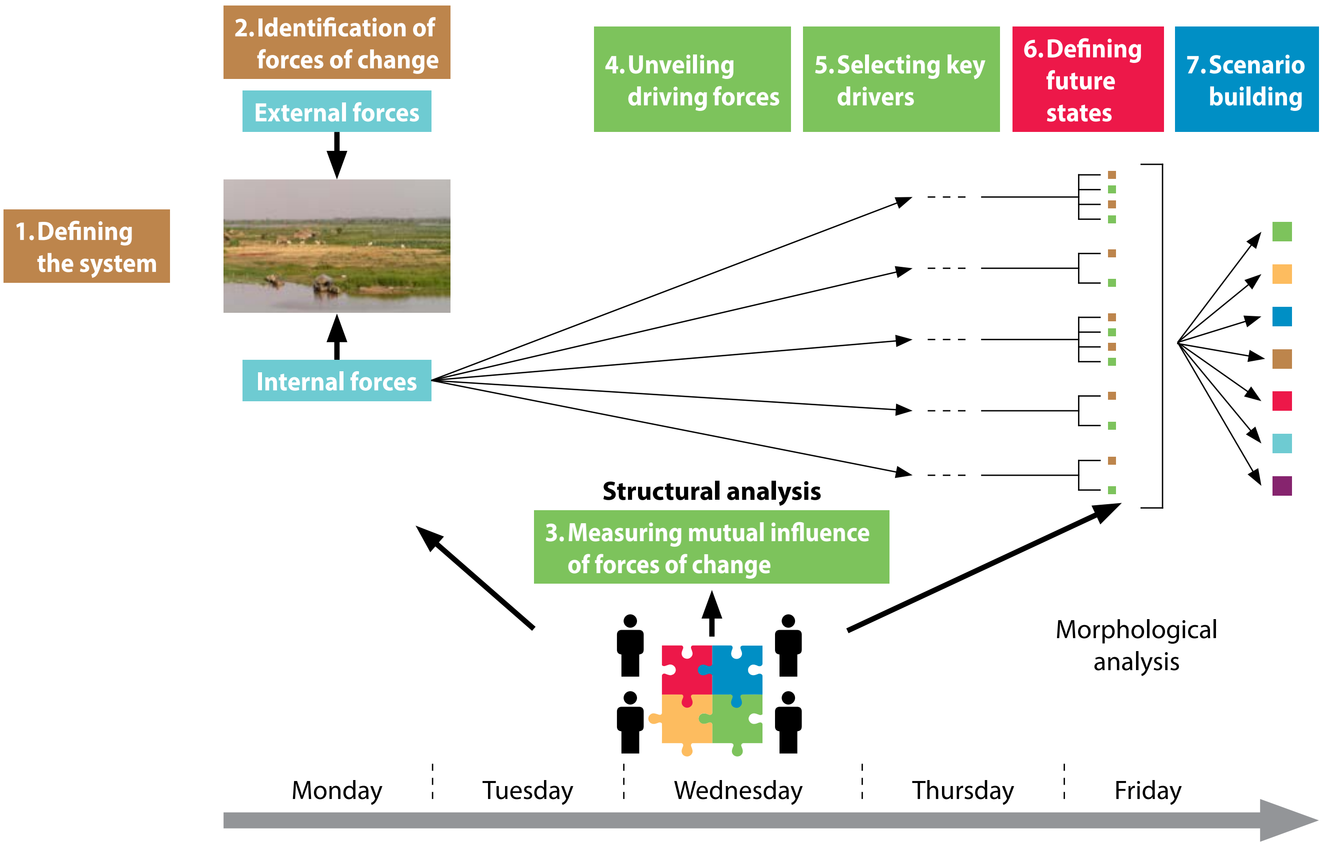


Figure 6. Key steps in the participatory scenario-building process.

directly influence them (i.e. external forces are not able to be influenced, while internal forces are those where some or all actors have the capacity to modify the future state of the force). The internal and external forces were then grouped under social, technical, economic, environmental, policy and political (STEEP) themes to capture the complexity of dimensions at play in these systems.

Output: Temperature changes and climate variability were identified as external forces and therefore were not included in further analysis. Table 2 details the 49 internal forces identified by the participants, their agreed-upon definitions and their categorization by STEEP themes. In essence, these forces characterize the dynamics of aquatic agricultural systems in Madagascar, Mozambique, Malawi and Zambia.

Measuring mutual influences (structural analysis)

Process: This step involved using the agreed-upon internal forces to estimate the direct influence of each force on each other force. Understanding the relationships between forces is an important component because it shows what "drives" the system and how it "moves." The output was a binary assessment of either the existence or the absence of a direct influence. Important here was the clarification of *direct* influence. Through discussion in two groups, participants estimated if each individual force of change had a direct influence on another force (i.e. if a change in one force would cause an immediate change in another force without needing any other force to act, and this change

Number	Name	Acronym	Definition
Policy			
2	Political will	Pol_Will	To what extent fisheries and aquatic agricultural systems are priorities in policy at national level and translated into policies, legislation, strategies and frameworks
3	Policy implementation	Pol_Imp	How policies are translated into action (including legislation, accountability systems and resource allocation)
4	Stakeholder interaction	Stak_Int	The state of relations and interactions between actors in policy-making processes
5	Trade policies	Trad_Pol	The presence and orientation of trade policies related to fish and aquatic agricultural products
Environmental			
6	Natural resources management	Nat_Res_M	How local stakeholders manage natural resources (i.e. land, water, forests and biomass)
7	Land availability	Land_Av	The amount of land that is available for use by aquatic agricultural systems-dependent local people
8	Water availability	Wat_Av	The amount of water that is available for use by aquatic agricultural systems-dependent local people
9	Water quality	Wat_Qual	The state of water quality in aquatic agricultural systems
10	Soil quality	Soil_Qual	The state of soil health in aquatic agricultural systems (i.e. chemical, physical and biological properties)
11	Biodiversity	Bio_Div	Local species diversity in aquatic agricultural systems (i.e. flora and fauna, both wild and domesticated)
12	Multifunctionality of aquatic agricultural systems	Multi_Func	Other goods and services provided by aquatic agricultural systems besides fish, crop and livestock production (e.g. income, jobs and ecosystem services)

Economic			
13	Land competition	Land_Comp	The extent to which aquatic agricultural systems lands are developed for land uses other than agriculture (including urbanization)
14	Access to financial resources	Fin_Ress	Access to financial resources to invest in the development of fish and aquatic agricultural systems
15	Alternative livelihoods	Alt_Live	Ability to diversify activities beyond fish and aquatic agricultural systems
16	Land tenure	Land_Ten	The level of security people have in land ownership and use (i.e. manifested in titles and user rights)
17	Access to water	Acc_Wat	Access to and use of water resources, including irrigation technologies, in relation to the development of fish and aquatic agricultural systems
18	Access to land	Acc_Land	Access to land in relation to the development of fish food systems and aquatic agricultural systems
19	Entrepreneurial opportunities for women and youth	Ent_Opp	Ability for resource-poor people, including women and youth, to become entrepreneurs in aquatic agricultural systems and beyond
20	Demand for fish and aquatic agricultural systems products	AAS_Dem	The level of demand for fish and aquatic agricultural systems products, including local and national demand
21	Access to input markets	Input_Mark	To what extent local producers and investors have access to and use inputs (e.g. seed, feed, chemicals, etc.) in order to engage in aquatic agricultural systems value chains
22	Access to output markets	Output_Mark	To what extent the local producers can sell their aquatic agricultural systems products for profit (including market information provision)
23	State of market openness	Mark_Open	To what extent aquatic agricultural systems-related products can flow freely within the region
24	Profitability of aquatic agricultural systems activities	AAS_Prof	The net income resulting from engaging in aquatic agricultural systems activities
25	Type of people involved in aquatic agricultural systems activities	AAS_People	Who is engaged in aquatic agricultural systems activities (different socioeconomic and ethnic groups)
Technical			
26	Capture fisheries management	Cap_Fish_M	Methods of capture fisheries management by stakeholders, including fishing methods
27	Agricultural and fishing practices	Ag_Fish_Pract	The type of aquatic agricultural systems practices that people pursue based on a combination of inputs, skills and knowledge, culture, and values
28	Loss management technologies	Loss_Mngt	To what extent there are technologies available that can be used by local people (accessible and affordable) in order to manage production and postharvest losses
29	Production technologies	Prod_Tech	The type of technologies that can be used by local people to produce aquatic agricultural systems products (e.g. availability of high-productivity technologies and low-external-input-based technologies)
30	Quality of inputs	Qual_Input	The quality of inputs, including seeds, feed, chemicals, etc., that are locally available
31	Connectivity and information flows	Connect	The state of communication infrastructure
32	Data (information) availability	Data_Av	Information availability and quality, both technical and economic, including all levels from the national to the local
33	Leadership capacities	Lead_Cap	The competency level of leaders to perform their expected role

34	Local capabilities	Loc_Capab	Level of local capabilities of individuals and organizations or collectives in managing fish and aquatic agricultural systems
35	Capability development	Cap_Dev	To what extent local people and organizations can access and use sources of knowledge, skills and services in order to improve their capabilities
36	Research for development	R_4_D	The extent to which local, national and international research systems have the capacity to interact with local stakeholders in relation to their needs, opportunities and determining priorities
37	Processing technology	Proc_Tech	The type of technologies that can be used by local people to process aquatic agricultural systems products
Social			
38	Learning opportunities	Learn_Opp	Who in aquatic agricultural systems has access to what kind of learning opportunities
39	Youth in aquatic agricultural systems	Youth_AAS	The role of youth in aquatic agricultural systems
40	Population dynamics	Pop_Dyn	The changes in size and age composition of the population dependent on aquatic agricultural systems (including migration)
41	Relative attractiveness	Rel_Attr	Relative attractiveness of aquatic agricultural systems areas compared to non-aquatic agricultural systems areas
42	Economic and social inequalities	EcSoc_Ineq	The level of social-economic inequalities within aquatic agricultural systems
43	Community participation	Com_Part	To what level communities are involved in local decision-making processes in aquatic agricultural systems
44	Relations between government and traditional leaders	Gov_Trad	How rights and duties are shared between local government and traditional leaders (statutory vs. customary rule)
45	Interactions between interest groups	Int_group	The nature of the interaction between different socioeconomic interest groups related to fish and aquatic agricultural systems
46	Gender relations	Gend_Rel	The type of relationship between men and women, young and old in aquatic agricultural systems based on roles, social norms, attitudes, behaviors and practices that condition their involvement in aquatic agricultural systems activities and their access to productive and natural resources
47	Local perceptions	Loc_Perc	The local perception of individuals and institutions towards the potential development of aquatic agricultural systems
48	Transportation infrastructure	Trans_Inf	The state of transportation infrastructure from and to aquatic agricultural systems areas
49	Aquatic agricultural systems interest	AAS_Int	To what extent different types of organizations prioritize the development of fish and aquatic agricultural systems (i.e. international and regional communities, donors, foundations, philanthropists and the private sector)
50	Health status	Health	The health status of people engaging in aquatic agricultural systems activities

Table 2. Forces of change and their definitions.

can be clearly and logically explained). The participants had to look out for three sources of error while deciding influences: confusion in the direction of causality, indirect influence (where an intermediate force links the two forces) and co-variation (two forces evolving similarly as another force is influencing them both simultaneously). Assessment of the estimated influence between two forces was represented through a binary scoring system {0,1} and recorded in an influence/dependence matrix. This was then entered into structural analysis software to calculate these mutual influences and provide a quantitative basis to identify key drivers from which scenarios could be built.

Output: Much of the discussion centered on whether the influence was in fact *direct*. There were many forces of change that participants initially identified as having a direct influence on another force. Further interrogation of the influence showed that the interaction often happened indirectly through another force. For instance, policy implementation was initially identified as having a direct influence on agricultural and fishing practices. However, further discussion led to the conclusion that the influence occurred through the types of production technologies used in aquatic agricultural systems. The existence of these indirect relationships was further explored when the influence/dependence graphs were generated (see the "Unveiling the driving forces" section below), reiterating that when a force does not have *direct* influence on another, it can still have *some* influence.

Debate in these mutual influence sessions highlighted the importance of defining the forces of change within the system earlier in the process. This debate allowed for deeper examination and identification of distinct elements of similar forces. For instance, conversation about critical differences in the forces of land availability, land tenure, land competition and access to land emerged in reference to the Barotse land in Zambia's Western Province. Participants discussed how, even in a place with plenty of land, a level of security in having access to the land through rights and tenure was crucial for aquatic agricultural systems activities.


Photo Credit: Felix Clay/Duckrabbit

Smoking fish in Mongu, Western Zambia.

Participants discussed water availability for aquatic agricultural systems and the role of policy implementation, including how it can directly change local perceptions and the interest of other aquatic agricultural systems actors through such things as incentive schemes. Discussion showed how trade policies could potentially directly influence the demand for fish and aquatic agricultural systems products (e.g. a policy that promotes the consumption of Zambian tilapia) and capture fisheries management (e.g. trade policies to export raw tuna could influence handling, capture and processing of the fish).

Unveiling the driving forces

Process: Driving forces are the most influential in determining the future orientation of the system. They can produce either desirable or undesirable outcomes. Identifying driving forces is a crucial step in the scenario-building process because these forces are used to build the scenarios.

The key output from the structural analysis is the variables total strength graph that plots each force along two axes according to its weighted total influence and total dependence. The graph visualizes the position of the forces and determines their role according to the quadrant they sit in. Each quadrant corresponds to specific characteristics of the forces as indicated in Figure 7. There are five categories of forces:

Drivers (upper left quadrant): drivers are highly influential and independent of influences from other variables.

Leverages (upper right quadrant): these are both influential and dependent. They can drive the system but are also driven by the way the system evolves. They contribute to amplifying the direction the system is taking.

Outputs (lower right quadrant): they have little influence over the future direction of the system and are very dependent on what happens to the other forces.

Outliers (lower left quadrant): these forces behave independently from the system and usually represent very specific issues that are not relevant. They need to be discussed because they can sometimes represent forces not yet strong enough to change the system, but that have potential to do so in the future.

Bunch (the area along the axes): their role in the system cannot be clearly identified.

Output: Over 2000 binary interactions between the 49 forces were analyzed to produce a graph of the total influences (Figure 7). The forces were relatively evenly scattered across the four quadrants, indicating that aquatic agricultural systems in the four countries in southern Africa are complex systems affected by multiple direct and indirect forces, each exerting a different level of influence.

The key drivers of aquatic agricultural systems were found to be the importance of policies (land tenure, trade) and their implementation, and competition for resources (land, water and financial). The main levers of change were agricultural and fishing practices, access to water and land, and profitability of aquatic agricultural systems enterprises. In Figure 7, the blue circle contains the forces selected for building future scenarios of aquatic agricultural systems.

It was acknowledged that in such a complex system, with analysis of around 2000 interactions, the results must be interpreted carefully. For instance, an outlier force, though low in influence and dependence, is still important because it can have a big impact if combined with other forces.

Linkages deemed important by participants in discussions were not necessarily apparent in the influence/dependence matrix. For example, entrepreneurial opportunities for women and youth (variable 19) did not emerge as a key driving force despite discussions about how it directly influences local capabilities, capability development, community participation and gender relations.

Selecting the driving forces for scenario building

Process: Following a structural analysis, it is possible to identify and select driving forces to frame scenarios of plausible future states. The number of forces must be balanced; the more numerous the forces, the more complicated the scenario-building process. Conversely, including too few forces oversimplifies the scenarios and wastes the information produced during the previous steps. The focus is on the strongest direct drivers and, if needed, the strongest direct leverages (those that are the least dependent).

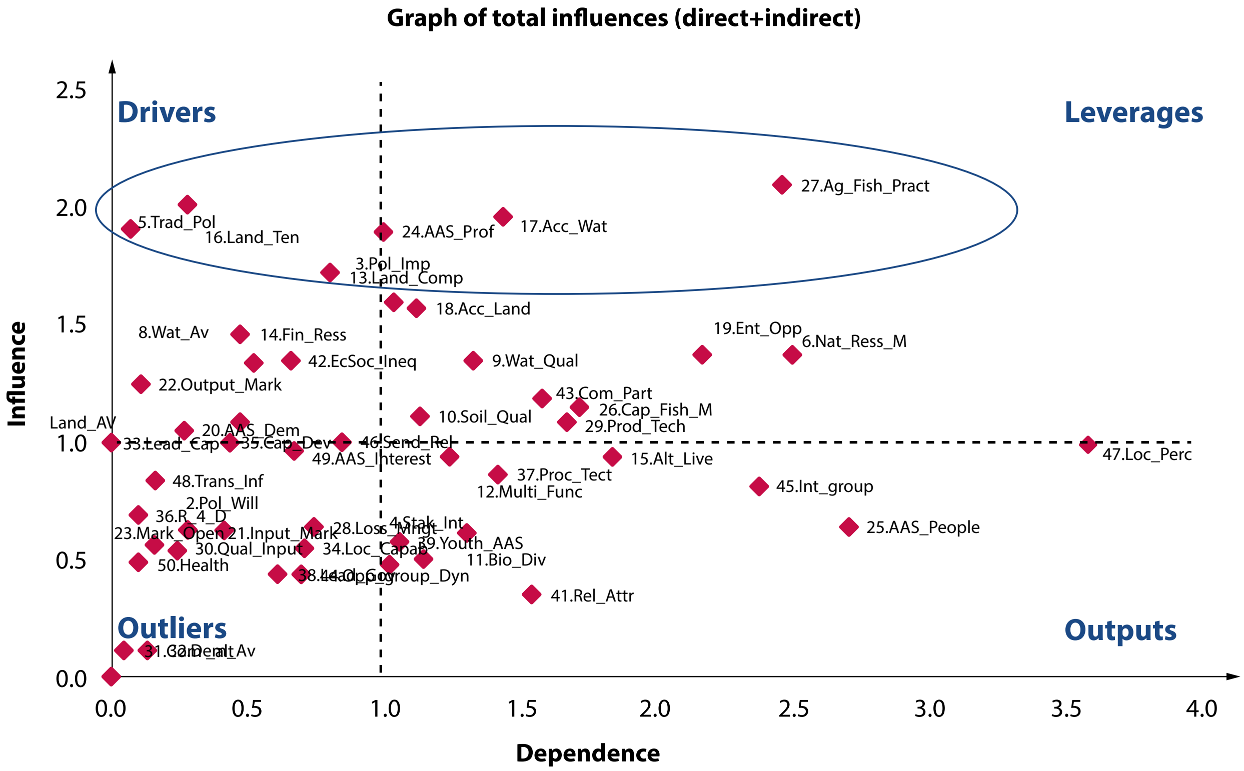
Output: Seven key driving forces were selected (see the oval in Figure 7). These forces are summarized in Table 3.

Defining the future states of the driving forces (morphological analysis)

Process: The purpose of this step was to define a number of possible future states, including desirable, nondesirable and alternative options for each driving force. In two separate groups, participants brainstormed possible future states of the key driving forces in 2030. The future states were then named and further described.

The groups assessed if any of the future states were incompatible with other states. Two states are incompatible if the described elements of each future cannot logically and plausibly coexist. Software was used for selecting compatible states to build the scenarios.

Output: Thirty plausible future states were identified across the six driving forces (Table 4). The largest number of states (six) was identified for land tenure and competition, while the least number of states considered plausible was for access to water (three).



(Intellectual property rights: CIRAD 2010. Authors: Robin Bourgeois and Franck Jésus).

Figure 7. Graph showing total influences for variables, based on the influence/dependence matrix.

Building scenarios

Process: This step consists of creating scenarios from the driving forces and the plausible states. A scenario is not a prediction or forecast. Rather, it is a possible combination of different states. What matters in scenario building is that the scenarios are broad enough to imagine multiple and contrasted transformations. These transformations can be desirable or undesirable for some or all participants.

After identifying the incompatibilities across states, the participants made a decision on how many scenarios to produce. Typically, only three scenarios are produced in scenario-building activities, spanning a "positive/desirable" scenario, a "neutral/trend/status quo" scenario and a "negative/adverse" scenario.

Output: Through brainstorming, group discussion and eliminating incompatible states, the group developed 18 distinct scenarios. Of these, the participants chose six scenarios to be named, defined and further discussed (Table 5). The most-desirable scenario was considered to be "aquatic agricultural systems sustainable development goals."

Expanded descriptions of the possible scenarios for the future of aquatic agricultural systems in southern Africa are presented in the following section.

Variable number	Force	Definition
5	Trade policies	The presence and orientation of trade policies related to fish and aquatic agricultural products.
24	Profitability of aquatic agricultural systems activities	The net income resulting from engaging in aquatic agricultural systems activities.
17	Access to water	Access to and use of water resources, including irrigation technologies, in relation to the development of fish and aquatic agricultural systems.
27	Agricultural and fishing practices	The type of aquatic agricultural systems activities that people pursue based on a combination of inputs, skills and knowledge, culture, and values.
16, 13	Land tenure composite with land competition	The level of security people have in land ownership and use (as manifested in titles and user rights), combined with the extent to which aquatic agricultural systems lands are developed for other uses (including urbanization).
3	Policy implementation	How policies are translated into action (including legislation, accountability systems and resource allocation).

Table 3. Driving forces used to build scenarios.

Driving force	Plausible future states					
Land tenure and competition	**Equitable rights base (land for all)** An equitable land distribution policy exists, with designated land-use rules and systems for land titling, to guarantee tenure security for aquatic agricultural systems actors and provide ecosystem services, minimizing competition from non-aquatic agricultural systems actors.	**The end of competition (no more aquatic agricultural systems)** Aquatic agricultural systems are unsuitable for habitation and livelihoods. There is no land and no competition.	**Total government control** All land belongs to the government, and access and titling is politicized (managed at the discretion of the politicians).	**Wild competition** Everybody competes for land in a situation where there is no established system for management control.	**Land for a few** There is land but titles are only secure for a few people. The richest take advantage of the land, engaging (or not) in aquatic agricultural systems and controlling the system, excluding resource-poor people and discriminating against marginalized groups.	**Local control** Titles and land competition are ruled by local decision-making processes, either customary or co-management decisions at the community level.
Access to water	**Water for all** There is universal and equitable water access for all people in aquatic agricultural systems areas in southern Africa for all aquatic agricultural systems activities, including ecosystem services.	**No more water** Water resource depletion causes the end of aquatic agricultural systems activities.	**Water for a few** Exclusion of some people from accessing water.	**Water scarcity** Water deficit impacts on aquatic agricultural systems activities.		
Trade policies	**Full regional trade liberalization** Full liberalization with unrestricted movement of fish and aquatic agricultural systems products across southern Africa.	**Total protectionism** Abolition of trade liberalization and trade barriers between aquatic agricultural systems areas.	**Exploitative protectionism** Total protectionism, where aquatic agricultural systems areas with bargaining and financial power are able to dominate through their trade policies.	**Ineffective trade policies** Ineffective trade policies with contradictory tariff regimes and/or protection of interests of select industries and elite.	**No trade policies** No trade policies.	
Agricultural and fishing practices	**Labor intensive** Use of state-of-the-art labor-using technologies and practices that comply with set standards and enable positive and collaborative interactions between interest groups.	**Blow them all** Fishing and agriculture practices are characterized by widespread use of poisonous chemicals, explosives, poisoned nets, dynamite and foreign species.	**Low external input** Dominant use of practices that require low external inputs.	**High tech** Use of high-tech, mechanized, automated practices that are capital intensive.	**No agricultural and fishing practices** There are no agricultural and fishing practices.	
Profitability of aquatic agricultural systems activities	**Out of poverty** The poorest people in aquatic agricultural systems have surplus income to meet their needs, including for maintaining their production activities, funding their children's education and attaining productive health status.	**Exploitative profitability** The gap between the resource-poor and rich has expanded, resulting in people no longer carrying out aquatic agricultural systems activities.	**Into poverty** Low to meager income-earning opportunities and repetitive natural disasters perpetuate poverty, with no opportunity for households to further develop their aquatic agricultural systems activities.	**No more aquatic agricultural systems** There are so many easy ways to make money that nobody is interested or wanting to engage anymore in aquatic agricultural systems.	**Payment for global heritage services** Net income generated by aquatic agricultural systems comes from public subsidies provided to maintain heritage and ecosystem services. This income is sufficient to satisfy the needs of those involved in aquatic agricultural systems.	
Policy implementation	**Inclusion** Process and procedure include strong laws around accountability, joint participation in development of policies and monitoring with allocated funds, and possible policies are designed and implemented on time and adhered to by all, including politicians.	**No implementation** No inclusive, systematic policies are being implemented, as there are no structures to translate them into action.	**Nonsupportive implementation (top down)** Policies that ignore the needs of the resource-poor are being implemented in a top-down, strict, inflexible manner.	**Chaotic implementation** Policymakers have no relevant expertise to implement and monitor policies in line with accountability systems.	**Ad hoc implementation** Policies are only developed and implemented as needs arise.	

Table 4. Possible future states of driving forces in 2030.

WORKSHOP METHODOLOGY AND OUTPUTS

	Scenario name	Plausible future states					
		Land tenure and competition	Access to water	Trade policies	Agricultural and fishing practices	Profitability of aquatic agricultural systems activities	Policy implementation
Positive scenarios	Aquatic agricultural systems sustainable development goals	Equitable rights base (land for all)	Water for all	Full regional trade liberalization	Labor intensive	Out of poverty	Inclusion
	The road to China?	Total government control	Water for a few	Total protectionism	High tech	Out of poverty	Ad hoc implementation
	From the grassroots	Local control	Water for all	Exploitative protectionism	Low external input	Out of poverty	Ad hoc implementation
Negative scenarios	Everything but aquatic agricultural systems	The end of competition (no more aquatic agricultural systems)	Water for all	Full regional trade liberalization	No agricultural and fishing practices	No more aquatic agricultural systems	Ad hoc implementation
	Save yourself, if you can!	Wild competition	Water scarcity	Full regional trade liberalization	High tech	Into poverty	No implementation
	Highway to poverty	Local control	Water for all	No trade policies	Blow them all	Into poverty	Ad hoc implementation

Table 5. Future scenarios for aquatic agricultural systems in southern Africa.

Process: Narratives were produced for six scenarios. Each narrative details how the driving forces would interact to craft more rounded scenarios. As there was insufficient time during the workshop to produce these detailed scenarios, a subset of workshop participants provided input into the crafting of the detailed scenarios. Care has been taken to ensure the narrative is compatible with the collective states.

Aquatic agricultural systems sustainable development goals

Future states: **equitable rights base (land for all), water for all, full regional trade liberalization, labor intensive, out of poverty** and **inclusion**

In 2030, an equitable land distribution policy with designated land use for aquatic agricultural systems is in place. This reflects the importance accorded to fisheries and aquatic agricultural systems in national-level policy and by various organizations, including international and regional communities, donors and the private sector. Land titling systems backed by legislation guarantee land availability, access and tenure security for aquatic agricultural systems actors and minimize competition from non-aquatic agricultural systems actors. As a result, access to water is universal and equitable for all aquatic agricultural systems activities, including the maintenance of important ecosystem services. Strong political will to support development and the sustainability of aquatic agricultural systems drives the development of strong laws around accountability, joint participation in the development of policies and monitoring of allocated funds. This enables the design and implementation of policies in a timely manner and in a way that encourages compliance by all, including politicians.

People dependent on aquatic agricultural systems are using labor-intensive technologies and practices that comply with set standards. There are positive and collaborative interactions between interest groups. Community-based capture fisheries management is practiced, with communities and both formal and traditional local institutions effectively managing the natural resource base. This produces effective outcomes, as the availability and quality of water, soil and biodiversity are sustainably managed. As a result, aquatic agricultural systems-dependent resource-poor communities are able to produce a larger range of ecosystem goods and services, diversify their livelihoods, and strengthen their livelihoods resilience. At the same time, the various interest groups with potentially competing uses of the natural resource base are negotiating to find win-win solutions through stakeholder discussions. Positive gender relations are prevalent, with women actively participating in community activities and decision-making and having equal access to productive resources. This results in increasing numbers of resource-poor women and youth engaging in aquatic agricultural systems activities. Access to suitable financial instruments, tools and financial resources means that those most commonly marginalized, such as women and youth, can generate and participate in entrepreneurial opportunities related to aquatic agricultural systems. This reduces the socioeconomic inequalities among community members across aquatic agricultural systems.

Local, national and international research actors are interacting with local stakeholders about their needs and opportunities, and setting priorities and developing technologies in line with those. The socioeconomically relevant production, postharvest and loss management technologies thus produced and adopted enhance the productivity of aquatic agricultural systems activities. Input markets are functioning efficiently and providing good-quality inputs, making them accessible and affordable to the resource-poor. Access to output markets is strengthened by good connectivity, market information availability and strong transportation infrastructure; increased demand for fish and aquatic agricultural systems products; and unrestricted trade movement of fish and aquatic agricultural systems products across the region. This enables the poorest people in aquatic agricultural systems to increase profits and have surplus income, which can be used to maintain their production activities, provide education for their children and attain productive health status. The highly profitable nature of aquatic agricultural systems activities attracts private investment. Supported by enabling policies and an active community leadership, aquatic agricultural systems-dependent resource-poor populations have access to remunerative, safe and dignified employment and business opportunities.

Local people and organizations are linked with external sources of relevant knowledge, skills and services, resulting in strengthened leadership capacities at all levels across aquatic agricultural systems and community-driven decision-making processes. Government and traditional authorities are acting in unison and dividing responsibilities and rights in an effective manner, building on their strengths, competencies and spheres of influence. The youth in aquatic agricultural systems are playing active roles as entrepreneurs and community leaders. With increased incomes and knowledge, resource-poor and marginalized groups, including women, have greater access to learning opportunities to build their capabilities, opportunities, self-confidence and self-esteem.

The road to China?

Future states: **Total government control, water for a few, total protectionism, high tech, out of poverty** and **ad hoc implementation**

In 2030, all land belongs to the government, with access and titling being highly politicized and managed at the discretion of the politicians. This total government control directs the use of aquatic agricultural systems lands, including the amount of land available and access to resources. Trade liberalization policies are abolished and trade barriers are established to limit the movement of aquatic agricultural systems products. The legislation and policies required to stimulate growth and the development of fisheries and aquatic agricultural systems are developed and implemented as needs arise. There is little proactive planning. A few strong lobbies and interest groups are able to influence the policy processes and decisions. Policies dealing with water allocation and access exist, but due to lobbying and vested interests they only favor a few elite stakeholders. Consequently, the majority of the resource-poor have limited access to aquatic agricultural systems resources. Policies favor the use of high-tech, mechanized, automated and expensive agricultural and fishing practices, including water-efficient irrigation technologies. These only add to enhancing opportunities for a small wealthy sector of elites. Priorities of local, national and international research systems are influenced by the needs of rich investors, and research investments to develop technologies that are poor-friendly are rare. The policies also direct how local stakeholders manage capture fisheries, including the type of fishing methods and broader use of natural resources. With local capabilities to manage fish and aquatic agricultural systems being limited, the opportunities for resource-poor communities to enhance the long-term sustainability of aquatic agricultural systems is restricted.

As only a small number of socioeconomic groups and individuals benefit from the policies and investment opportunities, this helps them capitalize on the protected market. They benefit from using aquatic agricultural systems to meet the increasing demand for fish and aquatic agricultural systems products. Input and output markets and communication infrastructure are developed. As a consequence, there is a positive local perception of the potential development of aquatic agricultural systems, and their relative attractiveness as places to live, compared to non-aquatic agricultural systems areas, is high. This enhances political will to support fisheries as a priority. This virtuous cycle is catalyzing even further investments in aquatic agricultural systems. The enterprises and investments create some employment opportunities for the resource-poor and previously marginalized groups. The resource-poor people dependent on these systems are able to generate adequate income to meet their needs, including providing education for their children and attaining productive health status.

But it is notable that exclusionary policies and practices have led to insecurity of land tenure, and the capacity to develop alternative livelihoods beyond employment is limited. This affects resource-poor women and youth, who have few entrepreneurial opportunities. With increasing socioeconomic inequalities within aquatic agricultural systems and reduced community engagement in local decision-making processes, youth begin to migrate.

Production-intensive technologies, concentrated resource ownership and use, and ad hoc implementation of policies all contribute to degraded water quality and soil health in aquatic agricultural ecosystems. The exploitative use of natural resources negatively impacts local biodiversity and the ecosystem services that underpin the multifunctionality and long-term sustainability of aquatic agricultural systems.

From the grassroots

Future states: **Local control, water for all, exploitative protectionism, low external input, out of poverty** and **ad hoc implementation**

In 2030, aquatic agricultural systems are characterized by local control. Issues relating to land tenure and land competition are resolved by local decision-making processes, through customary rules or co-management practices that see local institutions enabled by regional and national policies. Communities are highly involved in the local decision-making processes. Traditional leaders and the government enjoy a harmonious relationship and have a clear delineation of roles, responsibilities and authority. Local people are empowered and play an active role in policy-making processes. As a consequence, many aquatic agricultural systems-dependent communities have secure access to adequate land for aquatic agricultural systems production activities. Equitable water access is granted to all people in aquatic agricultural systems areas in southern Africa for all aquatic and agricultural activities. Sufficient environmental flows enable sustainable management of vital ecosystem services. With ample water and effective natural resource management practices, these multifunctional aquatic agricultural systems sustainably produce fish, crops and livestock, generating income and jobs.

Formal governance institutions have little focus on aquatic agricultural systems, and supporting policies and legislation are developed and implemented as needs arise. However, this is in an environment of trade policies and total protectionism. This results in restricted movement of fish and other aquatic agricultural systems products within the region. The high and increasing demand for these products gives aquatic agricultural systems communities strong bargaining and financial power. Local producers can command high prices and make substantial profits. There is access to financial resources to invest in aquatic agricultural systems development, as well as entrepreneurial opportunities within aquatic agricultural systems to diversify beyond fish.

The agricultural and fishing practices employed in aquatic agricultural systems are low-external-input systems, formed from the skills, knowledge, culture and values present within the aquatic agricultural systems community. They are affordable and developed to suit the needs of the communities. These practices, including capture fisheries management methods and production and processing technologies, enable sustainable use of natural resources and maintenance of water quality, soil health and biodiversity within the system. Research organizations are engaged in a dynamic dialogue with communities to assess their needs and develop technologies and management practices that are more profitable and sustainable.

This environment encourages resource-poor men, women and youth to engage in aquatic agricultural systems activities and capitalize on entrepreneurial opportunities. Communities play a major role in developing effective input and output markets. These communities have continual access to knowledge and sources to build their skills. There is a positive shift in interactions between socioeconomic interest groups and a reduction in socioeconomic inequalities within aquatic agricultural systems. The poorest people in aquatic agricultural systems have surplus income to meet their needs, including for maintaining their production activities, providing education for their children and attaining productive health status. Local individuals and institutions are positive about the future development of aquatic agricultural systems, and aquatic agricultural systems areas are viewed as relatively attractive places to live and work. This reduces migration out of these areas.

Everything but aquatic agricultural systems

Future states: **The end of competition (no more aquatic agricultural systems), water for all, full regional trade liberalization, no agricultural and fishing practices, no more aquatic agricultural systems,** and **ad hoc implementation**

By 2030, the overexploitation of natural resources in aquatic agricultural systems has left them degraded and unable to support livelihoods, and therefore unsuitable for habitation. There is little incentive or interest from the government towards sustainably managing aquatic agricultural systems, and policies are only developed and implemented ad hoc, as needs arise. Through full regional trade liberalization, there is unrestricted movement of fish and aquatic agricultural systems products, and thus aquatic agricultural systems products from elsewhere in the region supply the high local demand. However, the reliance on imports means prices are high and consumption rates of fish among the resource-poor are low, reflected in their poor nutritional status.

The input and output markets have disappeared. Local individuals and institutions have negative perceptions of the potential development of aquatic agricultural systems activities. Other activities and areas are seen as relatively more attractive. Communities are no longer participating in local decision-making about aquatic agricultural systems, and their access to finances for investing in fish and aquatic agricultural systems is no longer a priority.

Entrepreneurial opportunities for resource-poor people, particularly women and youth, have mostly disappeared from aquatic agricultural systems. Stakeholders have few incentives to engage in aquatic agricultural systems activities. Other livelihood opportunities are now easier and more profitable. These enable people previously involved in aquatic agricultural systems to diversify their livelihoods beyond, and to the exclusion of, fish production and aquatic agricultural systems activities. As many migrate to seek alternative livelihoods focused on other activities, the size of the aquatic agricultural systems population has dropped significantly.

Without interest in aquatic agricultural systems, land previously used for aquatic and agricultural production is abandoned. The land becomes unsuitable for any productive activities and thus is developed for other uses, such as urbanization. People's previous concerns about land ownership and access rights, including tenure, titling, land availability and competition, are no longer relevant.

Those still involved in aquatic agricultural systems no longer focus on managing natural resources to ensure long-term sustainability of the system. Fisheries management has been abandoned. As a consequence, production is reduced and production and processing technologies for aquatic agricultural systems products are not being used. With a small aquatic agricultural systems population and little interest in using water for irrigation or fish production, competition for water is low. Water is available universally and equitably. Paradoxically, the abundance of water offers the potential to rejuvenate some of the degraded ecosystems.

With no one pursuing aquatic agricultural systems activities, skills and knowledge are limited and eroding. The research system is not investing in aquatic agricultural systems technologies or knowledge generation. Socioeconomic inequalities are on the rise, as not everyone can access or is capable of engaging in alternative livelihoods.

Save yourself, if you can!

Future states: **wild competition, water scarcity, full regional trade liberalization, high tech, into poverty** and **no implementation.**

In 2030, there is no established system for land management and control in aquatic agricultural systems, and a state of unconstrained competition has arisen. There is intense rivalry for aquatic agricultural systems lands, including from urbanization, and there is very little security in land ownership as manifested in titles and user rights. Relations between the traditional leaders and the government are dysfunctional. Problems around land tenure and competition have dramatically affected access and the amount of land available for use by aquatic agricultural systems-dependent local people. Water has become scarce, and the decline in water availability and access negatively impacts the production activities of aquatic agricultural systems-dependent resource-poor people. Community participation in local decision-making processes is overridden by the scramble for land, water and profitability.

There is full regional trade liberalization with unrestricted movement of fish and aquatic agricultural systems products across the region. The implementation of policies relating to fisheries and aquatic agricultural systems is not inclusive or systematic, as there are no structures in place to translate them into action. In light of high demand for fish and aquatic agricultural systems products, the nature of interaction between socioeconomic interest groups involved in fish and aquatic agricultural systems has become increasingly strained, with aquatic agricultural systems activities overtaken by striving for individual profit.

Due to these combined pressures, local stakeholders are increasingly using unsustainable approaches to managing natural resources in aquatic agricultural systems. Restricted water availability and reduced water quality negatively impact the biodiversity of local aquatic agricultural systems. The decline in water resources, water quality, soil health and biodiversity has caused a loss of ecosystem services provided by aquatic agricultural systems. As a result, the ecological functioning and integrity of aquatic agricultural systems are compromised and are less able to provide for other goods and services besides fish, crops and livestock.

High-tech mechanized, automated practices are widely used to fuel agricultural production within aquatic agricultural systems. The high cost of these technologies and practices excludes resource-poor people. Increasingly, mechanized agricultural and fishing practices extend to capture fisheries production and processing. Research agencies are attracted to work in aquatic agricultural systems, but cater to the needs of the wealthy and influential few who dominate the production activities. Resource-poor communities dependent on aquatic agricultural systems increasingly lack access to money to invest in fish and aquatic agricultural systems products that are profitable. As a result, socioeconomic inequalities within aquatic agricultural systems have increased rapidly. Access to input and output markets is limited, despite access to communication infrastructure. An increase in the frequency of extreme climate events and natural disasters, such as drought and flooding, has resulted in low to meager incomes and perpetuates household poverty. The opportunity to further develop aquatic agricultural systems activities is diminished significantly, as is the possibility to diversify activities beyond fish and aquatic agricultural systems products for alternative livelihoods. Reduced productivity and production have led to very high food prices, exacerbating the challenge of food and nutrition security of local people. Entrepreneurial and capability-enhancing opportunities for resource-poor people, including women and youth, in aquatic agricultural systems and beyond have become increasingly limited. There are negative local perceptions about the potential future development of aquatic agricultural systems. There is widespread migration to urban areas by local youth, leaving women, children and the old to manage the households.

Highway to poverty

Future states: **Local control, water for all, no trade policies, blow them all, into poverty** and **ad hoc implementation**

In 2030, local decision-making processes, either customary or co-management-based, occur at community level and govern issues around land tenure and land competition. The land ownership and land use for aquatic agricultural systems activities, including which aquatic agricultural systems lands are developed for other land uses such as urbanization, is determined locally. This influences the amount of land available for use by aquatic agricultural systems-dependent local people and their access to this land for developing fish food systems and aquatic agricultural systems. Community control has provided universal and equitable water access to all people in aquatic agricultural systems areas in southern Africa for all aquatic and agricultural activities, as well as supporting vital ecosystems that underpin the system. Although the relationship between the government and traditional leaders is tenuous, communities play a strong role in influencing policymaking. However, no trade policies about fish and aquatic agricultural products exist, and policies are only developed and implemented on an ad hoc basis as needs arise. This means that legislation, accountability systems and resource allocation are minimal and may be incomplete and unconnected at times.

With high demand for fish and aquatic agricultural systems products but no effective governance policies, local stakeholders have turned to destructive agricultural and fishing practices to maximize production. These include the widespread use of poisonous chemicals, explosives, poisoned nets, foreign species and dynamite. These methods dramatically reduce water quality and soil health, including its chemical, physical and biological properties. This has led to a loss of local flora and fauna, both wild and domesticated species, that were previously a large part of aquatic agricultural systems.

Overexploitation and poor management of aquatic agricultural systems has degraded the ecosystem. Together with increasing extreme climate events and natural disasters, such as drought and flooding, people dependent on aquatic agricultural systems are receiving only low to meager incomes, which perpetuates household poverty. Access to money for investing in fish and aquatic agricultural systems has been drastically reduced, as have the possibilities for households to diversify their activities beyond fish and aquatic agricultural systems to alternative livelihoods. Research organizations do not engage with stakeholders, perceiving a lack of interest in using sustainable practices and technologies. This widens the distance between socioeconomic groups within aquatic agricultural systems. Despite the high access to input and output markets, communication infrastructure, and data, the quality of agricultural and fishing inputs has fallen drastically. There is no opportunity for aquatic agricultural systems-dependent households to further develop their aquatic and agricultural activities. The possibility of resource-poor people, particularly women and youth, to become entrepreneurs in aquatic agricultural systems and beyond is extremely limited. Local individuals and institutions are negative about the potential development of aquatic agricultural systems in the future. The options for aquatic agricultural systems-dependent resource-poor to enhance their capabilities are limited due to low incomes, drawing them into the vicious cycle of poverty, with women bearing the brunt of the situation. As a consequence, aquatic agricultural systems are experiencing widespread migration out of the areas, particularly by youth.

CONCLUSION

The scenarios developed through this participatory foresight analysis offer a rich resource for informing the development of a range of social, technical, economic, environmental, policy and political strategies needed to influence the food and agricultural systems associated with aquatic agricultural systems towards more robust and equitable trajectories. Importantly, this information has evolved from a transdisciplinary process with a wide range of stakeholders and through a systems lens, and as such, reflects the need for strategies and action plans to similarly reflect integrated and multisector responses.

Recognizing that there is heterogeneity among and within the four countries of focus, there is a need to scale down the scenarios to national, subnational and community levels to develop tailored and context-specific priorities and policy directions. Such an approach links global transformation and challenges to site-specific, local agriculture and rural development problems and decision-making processes. These scenarios can be used as tools for facilitating dialogue and building coalitions between rural communities, scientists, policy makers and civil society to inform future-focused research and development policies, practices and investments that shape pathways towards food and nutrition-secure futures.

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About the CGIAR Research Program on Aquatic Agricultural Systems
Approximately 500 million people in Africa, Asia and the Pacific depend on aquatic agricultural systems for their livelihoods; 138 million of these people live in poverty. Occurring along the world's floodplains, deltas and coasts, these systems provide multiple opportunities for growing food and generating income. However, factors like population growth, environmental degradation and climate change are affecting these systems, threatening the livelihoods and well-being of millions of people.

The CGIAR Research Program on Aquatic Agricultural Systems (AAS) seeks to reduce poverty and improve food security for many small-scale fishers and farmers depending on aquatic agriculture systems by partnering with local, national and international partners to achieve large-scale development impact.

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