Adaptive delta management for resilient food systems- Position paper

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Summary

Deltas are worldwide known for land and water interactions, be it nature, or be it their important contributions to agricultural production. Attractive for settlements, urbanization in deltas also has a downside effect: the characteristics that make deltas attractive, also make them vulnerable, which is exacerbated by climate change. Soil subsidence, increased salinity, risk of flooding and droughts make the food system vulnerable and creates uncertainties for the future. Adaptive delta management is used as an approach to deal with uncertainties and longer-term planning issues. This paper explores how adaptive delta management can contribute to the necessary transformations to enhance resilience of the food system and provides a framework to support this process.

Introduction

Deltas are the downstream part of rivers where the river flows into the sea and can extend over large areas. Deltas are generally low-lying grounds with little elevation, intersected by river branches. River sediments are deposited here, resulting in generally fertile soils. Examples of delta countries are Bangladesh and the Netherlands where the larger part of the country lies in the delta. Deltas offer many possibilities for connections to other countries over sea and to the hinterland over the river. As a result, deltas are ideal places for settlements and agricultural activities forming centres for food production and trade. Nowadays more than 500 million people live in and around deltas globally, representing seven per cent of the human population living on one per cent of the global land area (Nicholls et al., 2020). Next to this, many deltas are important areas of great ecological importance as well, featuring wetlands of high and unique biodiversity. Population growth and economic development threaten these ecosystems (Bucx et al., 2014).

The very same characteristics that make deltas attractive places also make them vulnerable. Being flat and low-lying makes them vulnerable for flooding from both the river and the sea. Climate-induced sea-level rise and extreme events as well as land subsidence increases this vulnerability. The associated inundation, salinity and waterlogging has severe impacts on agricultural production and consequently on livelihoods (Nicholls et al., 2020).

Not only the agricultural production in deltas is vulnerable; the overall food system becomes more vulnerable. Flooding of the river or the sea but also salinity and waterlogging affects subsequent food transport, food processing and the food distribution system because of damages and cut off of supply routes, and processing and storage facilities (van Berkum et al., 2018).

Realisation of the important role of deltas in economic activity worldwide as well as the central role of water management in deltas has led to the concept of Adaptive Delta Management (ADM) (MinV&W, 2010). The concept builds on the idea that an adaptive approach is needed towards water management, facing major challenges due to increasing uncertainties caused by climate and global change and by fast changing socio-economic boundary conditions (Pahl-Wostl, 2007). An adaptive approach entails a shift from prediction and control to a learning approach.

This paper explores the possibilities of using the ADM approach to help make food systems in deltas more resilient. The paper builds on the recently developed analytical framework for food systems, the so-called Food System Approach (FSA), and on the ADM approach that looks at socio-economic and environmental developments in an integrated way, aiming at flexible approaches for long-term development and providing ways to deal with uncertainties connected to such long-term development processes. By connecting the ADM approach, that originates from the water management field, with the FSA, originating from the agricultural field, the paper aims to improve the connection between water management and agriculture with a focus on deltas.

The paper first gives a short overview of the ADM approach and the FSA approach respectively, followed by a discussion on the links between the two approaches. It concludes with a proposed conceptual framework to intertwine the two approaches.

Adaptive Delta Management

Traditionally, natural resources management was characterised by a more or less unidirectional approach of designing and implementing measures. In the 1970s, realisation grew that this approach did not account for the natural variability and uncertainty of natural systems and often resulted in undesired effects. This led to the concept of Adaptive Management to support the management of natural resources under uncertainty (Holling, 1978).

Adaptive management is defined in different ways, initially as “an inductive approach, relying on comparative studies that blend ecological theories with observation and with the design of planned interventions in nature and with the understanding of human response processes” (Gunderson et al., 1995), later more generic as “a systematic process for improving management policies and practices by learning from the outcomes of management strategies that have already been implemented” (Pahl-Wostl et al., 2007).

Adaptive management in general entails “a systematic and structured process for continuing improving management policies and practices acknowledging our limited understanding of natural system’s behaviour” (Zevenbergen et al., 2018). Four phases are identified in a cyclic adaptive management process (Pahl-Wostl et al., 2006):

- Participatory policy formulation
- Management actions – Policy implementation

- Monitoring and evaluation
- Participatory assessment

Enabling elements in a successful adaptive management approach are (Zevenbergen et al., 2018):

1. A system approach in which uncertainty is acknowledged and 'information gaps' are identified,
2. Participatory decision making, and
3. Learning and experimentation to narrow down information gaps over time.

Transferring the Adaptive Management concept to the management of deltas, focusing on the water management issues, results in a process description as shown in

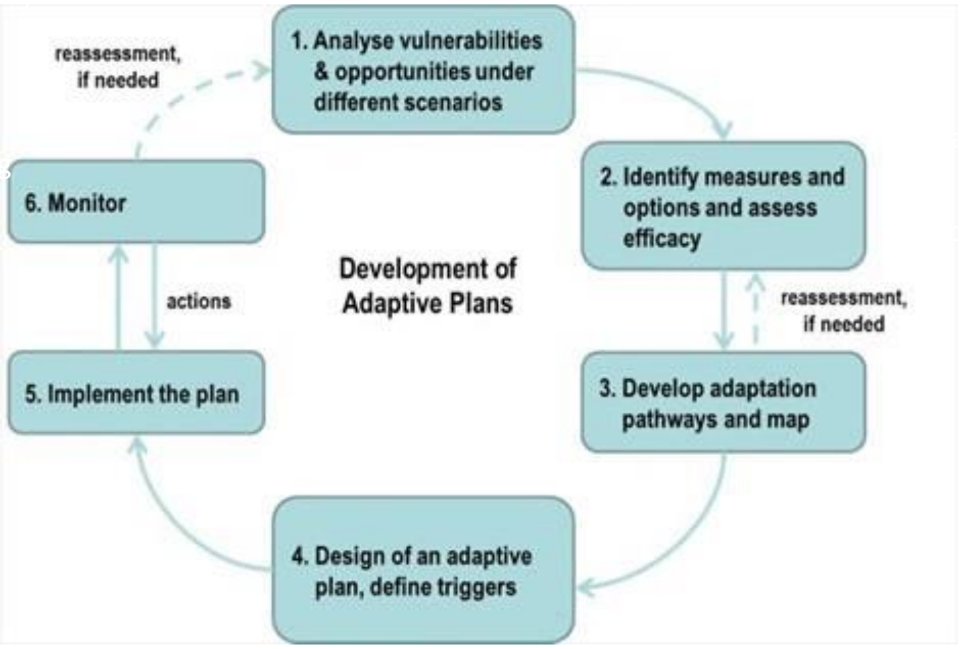


Figure 1.

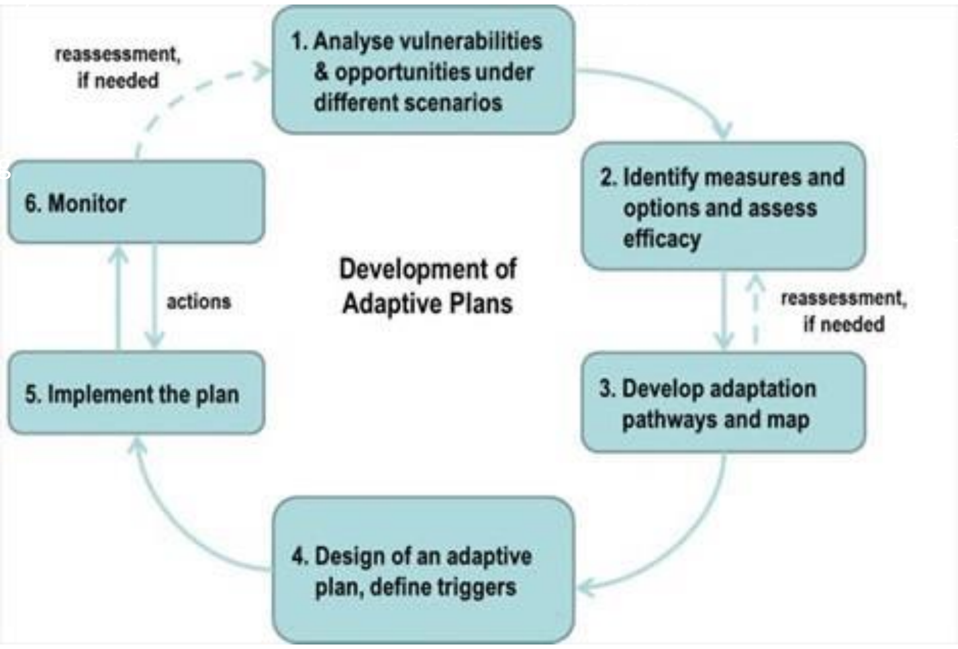


Figure 1 Adaptive Delta Management cycle (adjusted from Haasnoot et al., 2013 and van de Brugge & Bruggeman, 2015)

The steps in the Adaptive Delta Management cycle are described by Haasnoot et al (2013) and van de Brugge & Bruggeman (2015) as follows:

1. The first step involves conducting a problem analysis: where and when will problems occur under different scenarios? A problem occurs when policy objectives, such as safety, flooding, water quality or water level standards, are no longer met.
2. The second step involves exploring possible adaptation pathways, consisting of possible series of measures that provide a solution to the problem. Preparing different pathways makes it possible to explore what adaptation options are available.
3. In the third step, different adaptation pathways are evaluated, determining which measures need to be taken now and which measures should be deferred. The best adaptation pathway ideally provides the flexibility to respond to changes and still achieve the intended results.
4. The fourth step is formulating the adaptation plan. The intended measures as well as triggers to modify the measures in case of unwanted developments are defined.
5. The fifth step involves implementation of the plan. Short-term measures, including the measures necessary to keep options open in order to maintain flexibility over the long term, are implemented.
6. In the sixth step, a monitoring system is set up, which allows for tracking developments relevant to adapting the strategy or expediting or delaying implementation of the measures.

In addition to this process description, there is a need to have a general **vision** of what the future should look like, for instance in terms of sustainability. This includes general ideas about the future developments. This vision is included in the scenarios used in step 1. Step 2 can subsequently make use of the method of **back-casting**, looking at the desired future situation and then identifying the steps needed to go from the current situation to that desired situation (Figure 2) (Choudhury et al., 2012). Step 6 is needed for **learning**; the way the situation evolves may lead to adjustments one or more of the steps (also see Box 1).

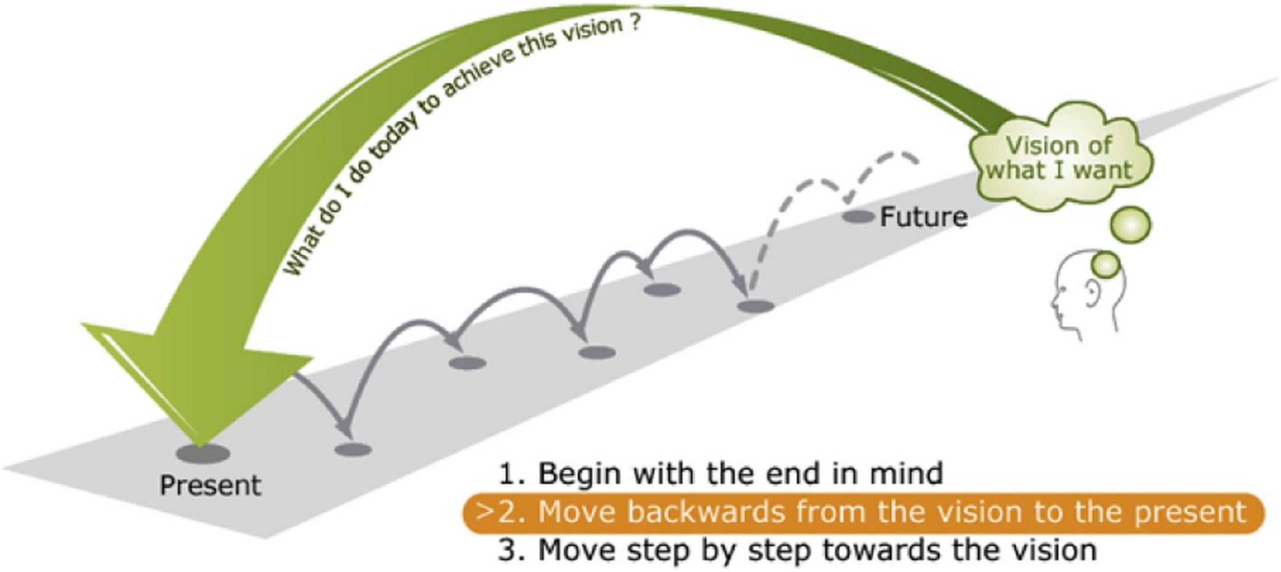


Figure 2 The back-casting process (in Bibri & Krogstie, 2019 from Holmberg, 1998)

Applying ADM in a Delta Plan thus entails developing a vision towards what the (far) future could look like. Then, through collating the available knowledge and developing scenarios to describe possible developments, in a process of back-casting an overall strategy is developed.

Casting back from the desired situation to the current situation, different pathways of change can be identified under different scenarios. These pathways can be evaluated on the basis of expected costs and benefits in view of uncertainty (Haasnoot et al., 2013). In developing pathways, it should be noted that pathways are not a one-on-one relationship between drivers and impacts (Béné et al., 2019). Measures that perform well under different circumstances and that provide options for future adaptation will generally be preferred. This leads to an adaptable strategy that should contain a learning element; it is not a masterplan that will be implemented but a plan that indicates the initial and future steps and possible adjustments in the steps. It should also contain the criteria that will be used to evaluate the progress of the plan. This strategy, once developed, needs to be 'put on the ground' by detailing the developments of all sectors that are linked, like agriculture. Throughout the implementation of the strategy the situation and developments are monitored and evaluated to ensure a learning process and possible adjustments of the strategy, the pathways or the vision.

In the Netherlands, a rethinking of water management is ongoing to counter the effects of climate change. Where originally, water management was focused on controlling and draining water, the new vision is one of containing and locally controlling the water and only draining of surplus water. A learning process is ongoing of land-use planning and implementing a range of different measures that build upon this changed vision (Ritzema & Van Loon-Steensma, 2018; Stańczuk-Gałwiaczek et al., 2018). Moreover, the Dutch Delta Programme, for ensuring long term flood protection and freshwater provision in the Dutch delta, explicitly looks far ahead (up until 2100) and aims for flexible pathways for adapting the Dutch delta to the possible impacts of climate change, taking into account different socio-economic development scenarios (Dewulf & Termeer, 2015; Jeuken et al., 2015). The Dutch Delta Programme includes a strong stakeholder involvement, including the agricultural sector (van Buuren, 2019). More details on examples of applying ADM, the Thames Estuary 2100 Plan and the Bangladesh Delta Plan 2100 are added in Box 1 and Box 2.

Box 1 The Thames Estuary 2100 Plan (Environment Agency, 2020)

The Thames Estuary 2100 Plan is designed to be adaptable to different projections for climate change and sea level rise. The Plan was developed in 2009 using the latest climate change guidance available at the time. It also made use of independent research on changes to fluvial flows, tidal storm surges, and sea-level rise, recognising that there was significant uncertainty surrounding future climate change. These uncertainties are addressed by ensuring actions that can be adjusted as the climate changes. The actions within the Thames Estuary 2100 Plan will happen over 3 phases:

Phase 1: 2012 until 2035:

- maintain and improve current flood risk management assets including walls gates, embankments and pumps
- protect land needed for future improvements to flood defences
- monitor how the estuary is changing

Phase 2: 2035 to 2050:

- raise existing flood walls, embankments and smaller barriers
- reshape the riverside through development, to improve flood defences, create habitat and improve access to the river

Phase 3: 2050 to 2100:

- decide and construct the best option for the future of the Thames Barrier
- adapt other flood risk management assets to work alongside this to protect the estuary

The Thames Barrier is expected to continue to protect London to its current standard up until 2070 (*vision*). The plan identifies different options for improving or replacing the Thames Barrier (*backcasting*). Because it is an adaptive plan, the final option is unlikely to be made until 2050 (*learning*).

Box 2 The Bangladesh Delta Plan 2100 (NWP, 2014; UNDRR, 2020)

Bangladesh encompasses the Ganges-Brahmaputra-Meghna river systems carrying huge amounts of water and sediment. Challenges to Bangladesh include river and coastal floods and cyclones intensified by climate change effects, as well as a range of socio-economic trends. The Bangladesh Delta Plan 2100 addresses these issues through a long term, holistic delta vision and adaptive strategy. The Plan, that was developed with involvement of a range of stakeholders, aims to deliver an umbrella development vision, strategy and implementation plan that can act as a frame of reference for new governmental policy. One of the most useful features of the document is that it allows for addition and amendments as and when new information becomes available.

The Food System Approach

The Food System Approach (FSA) comprises an analysis of all processes associated with food production and food utilisation: from growing crops to harvesting, packing, processing, transporting, marketing, consuming and disposing of food remains (van Berkum et al., 2018). Figure 3 shows the relationships between the food system outcomes and its drivers.

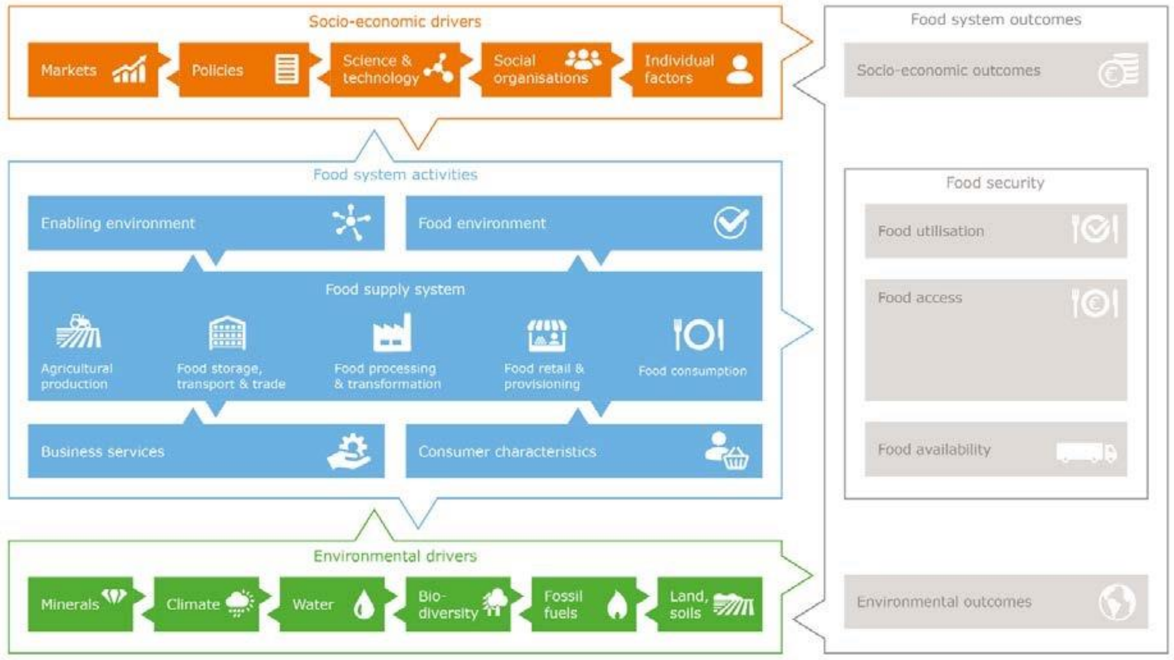


Figure 3 The relationships of the food system to its drivers (van Berkum et al., 2018)

The central, blue part in Figure 3 shows the food supply system describing the process of agricultural production through storage, transport and trade to food processing and transformation, retail and provisioning up to the final consumption of the food (from field to fork). This process is directly influenced by business services, consumer characteristics, the food environment and the enabling environment, that includes regulations like food safety regulations. The overall food system activities determine the food security that comprises food availability, food access and food utilisation.

The food system activities influence the socio-economic drivers (orange), for instance by providing jobs and incomes, but are also influenced by the socio-economic drivers, for instance by a changing consumption pattern. This interchange determines the socio-economic outcomes. Similarly, the food supply system influences the physical environment (green), for instance by using water for irrigation, and is influenced by the physical environment, for instance by a drought event. This interchange determines the environmental outcomes. The FSA thus looks at the food supply system but also at the socio-economic and natural environment it functions in, which can be considered its drivers (van Berkum et al., 2018). The outcomes and goals of the food system depend on the trade-offs between four domains (Figure 4) (WUR, 2020):

1. Safe and healthy diets that are made up of a balance of nutrients such as proteins, fats, minerals and fibre;
2. Inclusiveness and equal benefits that lower the differences in the accessibility, price and allocation of food;
3. Food security to ensure that enough food is produced safely for everyone in a growing global population; and
4. Sustainability and resilience, adapted to climate change and contributing to biodiversity.

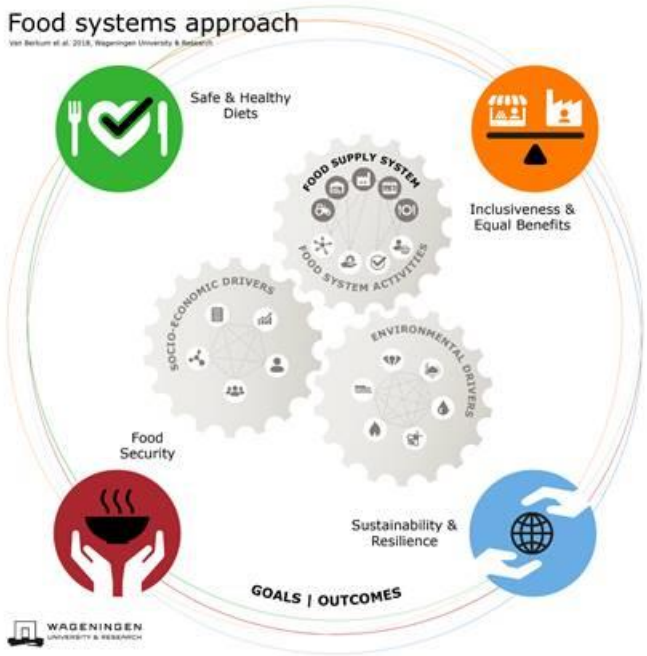


Figure 4 The food supply system as it functions in a trade-off between the four domains (WUR, 2020)

The FSA shows the composition of the whole food process functioning within the boundaries of the trade-off between the four domains. The global challenges around food security like natural resource depletion, climatic change impacts, biodiversity problems, population pressures, under- and overnutrition, unequal food distribution and economic prosperity require a transition of this food process towards a more sustainable and circular agriculture within a holistic perspective (van Berkum & Dengerink, 2019) to achieve a truly interdisciplinary approach (Dengerink & Brouwer, 2020).

Transitions can be described as the shift between two dynamic equilibriums that are described by system indicators. In the predevelopment phase, there is only little change in these indicators. Changes occur in the take-off phase and increase in the acceleration phase. In the stabilization phase, a new equilibrium is reached (Timmermans, 2006). This is shown in Figure 5.

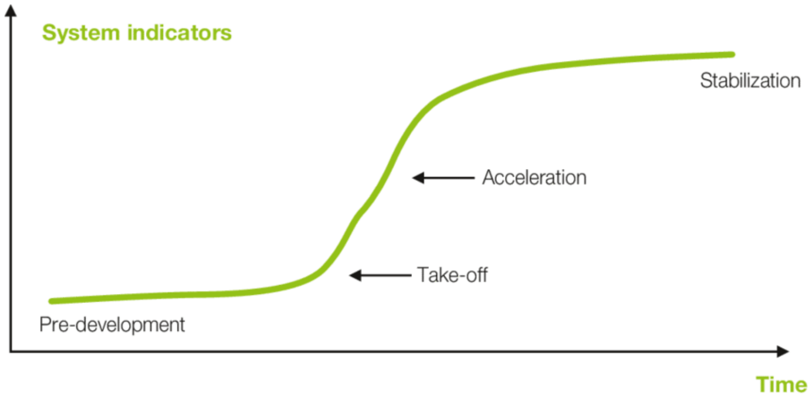


Figure 5 Changes in system indicators in the four phases of a transition

Transitioning towards a new, improved food system sometimes happens spontaneously. However, when considering desirable futures, it requires a strategic planning process that includes analysing the current system and its vulnerabilities, development of a vision of the future system, identifying and involving the relevant stakeholders, understanding the climate induced changes and a process of back-casting from the desired situation to the current situation. In developing a vision on the food system, the ultimate situation of the four domains can be described. Through the process of back-casting, scenarios to reach the goals for the four domains can be developed, also to identify the trade-offs. Based on this, the first steps can be taken to make the transition take off.

Links between ADM and FSA

Food production is closely connected to water management; agriculture accounts for 69% of annual water withdrawals globally (UN-Water, n.d.). Water management, especially in deltas, is crucial as in deltas, the risks of flooding, droughts and salinisation meet, sometimes simultaneously. With climate change, these risks become higher and there is thus a close connection between food security and ADM. Applying the ADM approach to the FSA can help with the necessary transition towards a more sustainable food supply. Vice versa, working on ADM in general should include the food system to enable a more sustainable food supply (see, for instance, Box 3 and Box 5).

Box 3 The Mekong Delta Plan (Korbee et al., 2019; Seijger et al., 2019)

The Mekong Delta is very vulnerable from floods, droughts and salinity, that hamper a prosperous and sustained economic development. The Mekong Delta Plan presents a vision to use the comparative advantages of the delta and focus on agro-business industrialisation. Better organisation of the agricultural producers enables a reduction of transaction costs, a platform for more sustainable land and water resources management, improvement of product quality and competitiveness. Diversification the provinces is necessary to adapt as much as possible to available land and water resources. Important examples of such diversification are a saline coastal zone with room for aquaculture integrated with mangrove restoration and in the upper delta-controlled flooding with water retention and fish farming in the flood season instead of a third rice crop. These are transitions proposed for the short to medium term. Still, large-scale measures to guarantee flood protection and freshwater availability may be required when at the longer term, climate change causes persisting sea level rise and droughts beyond the current expectations.

In many delta's worldwide, land reclamation and drainage of land has been practiced to increase land availability, generally for agricultural production. This also brought about the need for water control to shield the low-lying land against flooding and salinisation, and to optimize food production in the low-lying areas (see, among others, Box 4 and Box 5).

Box 4 Polders in Bangladesh

In Bangladesh, in the 1960s, polders, enclosures of high earthen embankments, were built to protect the land from the daily tidal inundation of saline water as well as to protect it from the monsoon rains and storm floods. The goal to enhance food production was prioritized over the warning of the 1956 Krug Mission that this would reduce tidal prism and cause upstream water logging (Rashid & Rahman, 2010). Upstream construction of the Farakka dam in 1974 reduced the flow in the rivers, and after initial success, over the years, drainage canals in south-west Bangladesh became increasingly inoperative due to siltation rendering vast tracts of lands waterlogged all year round. To deal with this situation, counter-intuitive, dikes were cut at strategic points to let freshwater from the river in. This so-called Tidal River Management solved the problem of waterlogging and increased the amount of fertile alluvial soil in the polder and agricultural production has risen again. In fact, it was in part a return to the traditional method of water management that existed before 1960. However, the related compensation to farmers is an institutional barrier for smooth implementation of this nature-based solution (Nowreen et al., 2013; Rahman, 1995; Warner et al., 2018).

Box 5 Lowering the dikes in the polder Noordwaard (Schut et al., 2010; van Staveren et al., 2014; Warner et al., 2018)

In the Netherlands, for many years, the risk of flooding was addressed by increasing the height of the embankments. The system of a smaller riverbed, with controlled flood plains where in case of high discharge the river discharge substantially increased, with smaller level increases, by widening the riverbed, submerging the controlled flooding areas. In recent days, in light of climate change and expected increases in peak river discharge, a change of mind took place and the risk of river flooding, also in combination with high tide situations, was countered through the 'Room for the River' programme that adopted a learning approach in implementing a new type of measures. The paradigm shifted from 'controlling the water' to 'accommodating the water'. One of the measures was to lower the dikes in the polder Noordwaard to provide extra space for flooding during high river water levels. Farmsteads are placed on mounds and roads are raised to ensure business continuity in case of a flood.

These three examples show the interrelationships between agricultural production and water management. In Bangladesh and Vietnam, water management measures support agricultural production. In the Netherlands, after an earlier period where water management was primarily designed to support agricultural production, a shift seems to have been made towards a situation in which agricultural land also supports water management measures. In Bangladesh, the local communities were important drivers for the changes and a real learning process took place. In the Netherlands, the local farmers had limited influence on the measures and initially objected, not so much against the concept of the project but against the unresponsive planning and implementation process (Warner et al., 2018). The latter underlines the need for a participatory decision-making process.

The examples show that FSA and ADM influence on each other and can provide mutual support in the area where they overlap (Figure 6). And the different approaches closely link to the elements used in ADM (Marchand & Ludwig, 2014; Zevenbergen et al., 2018). This situation asks for a common conceptual model that incorporates both the FSA and ADM elements.

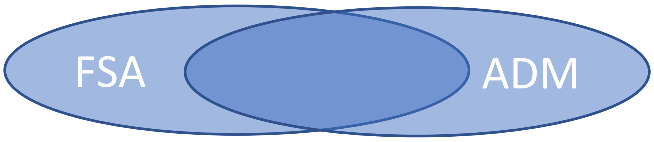


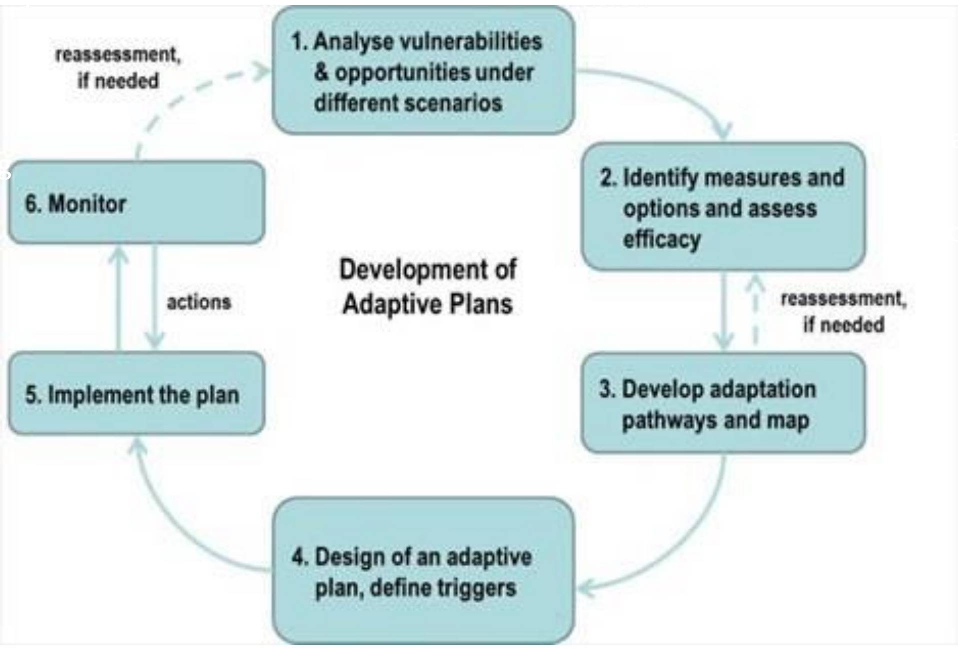
Figure 6 The overlap between FSA and ADM

A common conceptual framework

As stated above, better attuning between ADM and FSA ensures a more coherent approach in delta management that asks for a common conceptual model. Key elements of ADM are important points when considering transitions in food systems. For instance, from the above it becomes clear that in FSA, there is a need for a vision on the future food system that is shared among the stakeholders about the desired future situation. There is also a need for a shared image of the future when it comes to, for instance, climate change, but also demographic and other developments, as they put limitations on the desired future situation (see Box 6). Developing scenarios for these developments help to demarcate possible futures.

Box 6 Food and water interlinkages in Egypt (Terwisscha van Scheltinga et al., in prep.)

Egypt is facing increasing food security issues. Since the 1940s, the country is subsidising food to promote social equity and political stability. More and more, agricultural production in Egypt struggles with scarcity of the available water, an increasing population, and climate change and becomes increasingly dependent on other countries to meet its domestic food demand. The most significant drivers of the food system's outcomes are water scarcity and food subsidies. Application of the Water Footprint indicator on potential pathways for the Egyptian food system has shown that a smart combination of water policies and food policies is needed, applying water use efficiency including looking at possible dietary changes as well as importing crops from water abundant regions. In this context, there is a need for policy integration at high political level in which food and water are targeted side-by-side to identify all the trade-offs and synergies in food and water objectives and strategies while accounting for climate change.



The ADM cycle (Figure 1) will be used here for a first attempt to work out a conceptual framework for food systems in which the FSA (Figure 3) plays a central role. In developing the vision on the future situation, a view is developed on what the four domains of the food system (i. Safe and healthy diets; ii. Inclusiveness and equal benefits; iii. Food security; and iv. Sustainability and resilience) should look like in the future and how they interact with each other. The socio-economic and environmental drivers and outcomes can subsequently be included in scenarios to indicate developments over time for each element. The environmental drivers are influenced by the overall delta management to a certain extent, specifically the elements water and climate but also the element land/soil through land-use management and this is where the major overlap between FSA and ADM lies. The vision on the four domains together with the developments in the drivers leads to a view on what the food system outcome should look like as well as possible pathways to reach the vision. The vision is successively also used in the subsequent other steps of the framework by specifying how each element is targeted in that specific step (Figure 7).

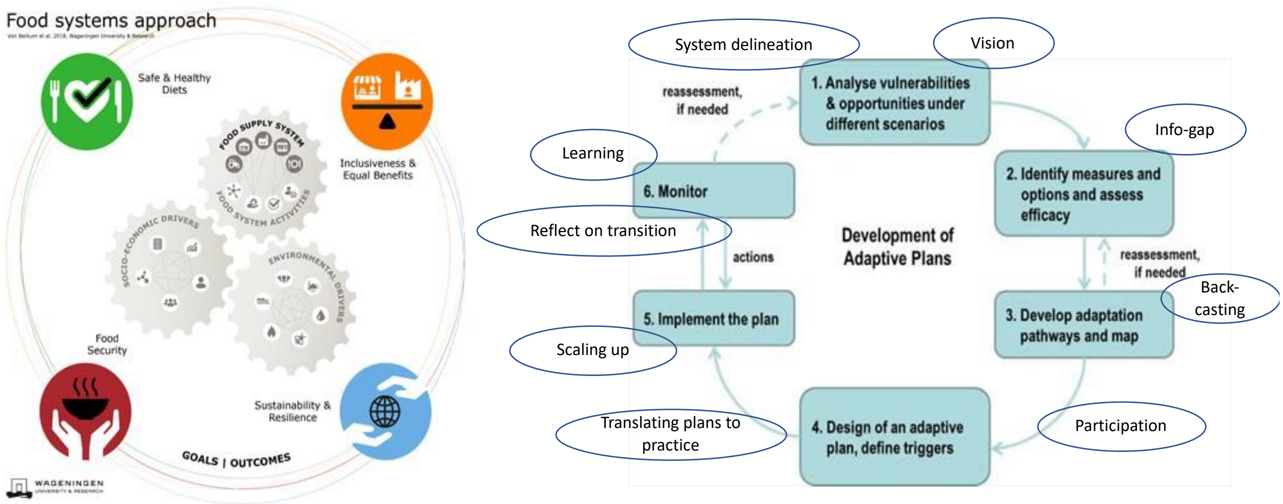


Figure 7 Linking FSA elements in the ADM cycle (adjusted from Haasnoot et al., 2013, van de Brugge & Bruggeman, 2015 and WUR, 2020)

Conclusion

Both FSA and ADM have the need for a vision and have to make the transformation under uncertain circumstances. And agriculture is generally the largest water user and needs closer cooperation with water management. ADM has adopted an approach that can be valuable for FSA and by adopting such an approach, the two processes can be intertwined. The ADM process, for instance, provides input on the availability of water and how this is organised relative to other water users like drinking water and energy. The FSA provides input on the trade-offs between health, equality, food security and sustainability. This combination, for which a first depiction is shown in Figure 7, is promising but needs further development, application and testing. Additional concepts may be needed to support further detailing of the options. The water footprint approach, for instance, can be used to assess national comparative advantages and disadvantages for different crops (Chouchane et al., 2020) and to ensure that water appropriation for human uses (food system) remains within ecological boundaries (Hogeboom et al., 2020) but also methods are needed to assess the value of water in agriculture (D'Odorico et al., 2020) and the food system in general.

This paper has provided a first concept of how FSA and ADM can be coupled to deal with the uncertainties of future developments and to ensure that the important linking components between the two approaches work together and reenforce each other. Testing is needed to further explore an adaptive approach towards FSA and the interlinkages between FSA and ADM. The approach as presented in this paper can be a basis for this testing and further elaboration on the interlinkages. To this end, a further program will be developed.

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