Downstream Voices

Wetland Solutions to Reducing Disaster Risk

by Fred Pearce

Wetlands International is an independent, not-for-profit organisation, active in around 100 countries. We safeguard and restore wetlands for people and nature.

This report was commissioned and published by Wetlands International, the Netherlands, in September 2014.

Publisher

Wetlands International
P.O. Box 471
6700 AL Wageningen
the Netherlands
Website: www.wetlands.org

Citation

Wetlands International, Downstream Voices: Wetland Solutions to Reducing Disaster Risk, Ede, 2014

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Wetlands INTERNATIONAL

Dried out lake in Akka, Senegal

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Hurricane Katrina survivors arrive at the Houston Astrodome Red Cross Shelter after being evacuated from New Orleans. Photo by Andrea Booher 31 August 2005

Foreword

While no one can overlook the increasing reports of devastating human suffering linked to water-related disasters like floods, droughts and landslides, few people realise the extent to which this has been caused or exacerbated by environmental degradation. Or in other words, mismanagement of land and water resources. And the consequent loss of natural environmental buffers, especially wetlands.

Climate change is of course part of the story – and is accentuating the hazards, but it is evident that climate is too often used as a mask for these underlying problems that play out at a landscape scale. Typically it's the poorest and most disadvantaged communities who are hit the hardest when a disaster occurs. They are often the least able to withstand and recover from the impacts and have the least say in managing the natural resources on which they depend. Wetlands International has witnessed these scenes and situations – after the 2004 Asian tsunami and in the recent Sahelian droughts for example. We have shown on a small scale that by helping local communities improve water resource management and the condition of wetlands, it is possible to make them become more resilient to the shocks and stresses of extreme weather events and better adapted to climate change.

Significantly, over the last decade, we have joined hands with the development and humanitarian NGOs to share our expertise and to work alongside them with vulnerable, rural communities. This has proven to be very effective – since together we have been able to develop, test and characterise a new way of working that can greatly enhance disaster resilience. We have identified the need for significant shifts in vision and approach. Restoring damaged environments is still rarely considered as a relevant part of the toolkit for disaster risk reduction. Another problem is field of view.

Often, the occurrence of hazards is considered a given and then measures are designed for use at a local, household or village level to prepare for or cope with these events. Little attention is paid to the fact that hazards often emerge from changes in land-use or water flows elsewhere, sometimes far away in the landscape and over long timescales. Big infrastructure investments such as dams for hydropower and irrigation, or upstream mining and forest clearance can create risks for downstream communities. There comes a point when just coping and recovering with the impacts is no longer viable. Landscape scale solutions are needed, often requiring the collaboration of government agencies and the private sector.

We are now keen to share our experiences and push for programmes that scale-up community-based approaches to address vulnerabilities alongside the root causes of natural hazards. What's needed is the adoption of integrated risk reduction programmes that combine ecosystem rehabilitation with other disaster risk reduction measures, at multiple scales, from the village level all the way up to the wider landscape or watershed. Together with our humanitarian partners, we are calling for more united policies, investments and practices from the humanitarian, development and environment sectors to help achieve this.

This book presents the case for ecosystem-based solutions and gives some insights and examples of an ecosystem approach to disaster risk reduction from India, Mali, Senegal, the Philippines and Kenya. Based on Wetlands International's work in this field over the past four years, the renowned international journalist Fred Pearce shines a light on the changes and challenges that vulnerable rural communities face in relation to environmental hazards – and how they can be assisted to take action that makes a real difference on behalf of their livelihoods and security. I hope you agree that these stories give good cause for optimism that a healthier, safer world for people and nature is possible to achieve, if new ways of thinking can be embraced and brought to scale.

Jane Madgwick, CEO Wetlands International

Introduction

Until recently, the world's response to inevitable climate change was based on producing ever more precise forecasts of what would happen locally – running ever more sophisticated climate models to generate data on the climate in Bamako, Mali in 2040, for instance – and then working out how to "adapt" to the change.

While ever bigger super-computers with ever more sophisticated climate models still attempt that, there is a growing realisation that we will never know in any detail what is coming down the track.

Some generalities emerging from the models may hold. Wet areas will generally get wetter and dry areas drier. Most of the world will be warmer most of the time. The extra energy in a warmer global climate system will tend to create more climatic extremes of all sorts – more storms of course, but also sudden cold spells, droughts even in wetter areas and worse floods even in the driest.

A defining feature of future climate is likely to be the greater unpredictability of day-to-day weather, says the Intergovernmental Panel on Climate Change's (IPCC) 2014 "fifth assessment" of the impacts of climate change. It noted: "Responding to climate-related risks involves making decisions and taking actions in the face of continuing uncertainty about the extent of climate change and the severity of impacts in a changing world." Or as report co-chair Chris Field put it: "The future doesn't ever turn out the way you think it will be. Being prepared for a wide range of possible futures is just always smart."

And that means that engineered adaptation is not always a realistic option. We simply won't know what we are adapting to. Creating engineered structures to protect people will be difficult, expensive and often either impossible or a waste of money. This new perspective suggests a different approach. Rather than an engineered response to known threats, it suggests paying much greater attention to ensuring our world is more resilient to whatever surprise a changing climate system may throw at us.

Thus the new report ditches past estimates of the impact of climate change on African rainfall patterns and crop yields – a yield reduction of up to 50 percent as soon as 2020 was one spectacular claim in the previous assessment, published in 2007. This time there are no headline grabbing statistics but the more measured – and arguably more useful – statement that "climate change will amplify existing stress on water availability and agricultural systems" in Africa and will "very likely reduce cereal crop productivity".

There is also emphasis given to how climate risks, though pervasive, are just one of a suite of challenges facing poor communities in particular "in a complex and changing world". It says that "climate-related hazards constitute an additional burden to people living in poverty, acting as a threat multiplier", but that "vulnerability is rarely due to a single cause."

Building resilience to climate change, therefore, needs to be part of wider systems of responding to a range of economic, social and environmental risks; one that places emphasis on natural ecosystems which grow and adapt to changing environments, rather than physical structures, which cannot. And that means that maintaining and regenerating natural ecosystems is often the most effective way of reducing the number of people and livelihoods that are in harm's way.

The IPCC report calls in particular for reforestation and, in coastal regions, for "increased mangrove, coral reef, and seagrass protection". As one former IPCC author, Colin Thorne of Nottingham University, puts it: "The best hurricane protection is three kilometres of mangroves."

Meanwhile farmers can build their resilience against floods, droughts, heat waves and hurricanes, by planting more climate-tolerant seed varieties, by enhancing wetlands, floodplains and lakes, by terracing hillsides, and by opting for farming systems such as agroforestry.

This report makes the case for addressing ecosystem degradation as one of the root causes of risk and vulnerability and for opting for ecosystem-based solutions as a way to reduce disaster risk and build community resilience. It focuses on water-related hazards in particular, as they make up a vast majority of risks, and are often exacerbated by inadequate water and natural resource management.

Fred Pearce, August 2014

Youth replanting mangroves in Indonesia

Restoration of coastline using permeable dams in Timbuk Sloko, Indonesia

Key lessons for policy and practice derived by Wetlands International

Wetlands International presents some pointers for governments, practitioners and the private sector for integrating ecosystems into resilience practice:

- **Healthy ecosystems make a crucial contribution to the resilience of communities and nations.** Ecosystems provide a range of benefits that help to reduce, buffer and in certain circumstances, mitigate hazards, as well as assist societies in adapting to increasing disaster risk and preventing risk accumulation. Fully-functioning ecosystems such as wetlands are also the basis of community resilience by sustaining livelihoods and providing water, construction materials and important products to local people. These services are furthermore vital to help communities recover after disaster strikes.

- In spite of the important contributions to resilience made by ecosystems, they are being lost and degraded at a rapid rate. Ecosystem degradation erodes nature's ability to regulate hazards, and to provide services such as food and water. The result is that more people are caught in a vicious circle of poverty, risk and vulnerability. This drives mounting social, economic and environmental losses and imposes ever greater costs of relief and rehabilitation on governments and donor agencies. In particular, the over exploitation of water resources and the draining of wetlands exposes societies to increased disaster risk, as the ability of wetlands to moderate floods and droughts, purify water, and support water and food security is impeded. **Ecosystem degradation should therefore be considered as one of the root causes of disaster risk.**

- Investing to address underlying risk factors is more cost-effective than disaster response and recovery, and contributes to saving lives and protecting assets. Hence **ecosystem-based approaches such as wetlands restoration and Integrated Water Resource Management should be at the centre of solutions to reduce disaster risk**, alongside other risk reduction measures. Ecosystem-based approaches should be considered as 'no-regret' actions – and always a good investment –as they serve multiple purposes, including the development of sustainable livelihoods and climate change adaptation and mitigation, in addition to reduced disaster risk.

- While long-term changes resulting from global warming will have impacts upon ecosystems and therefore on people, most immediate ecosystem degradation stems from flawed spatial planning or inappropriate water management policies and practices and may result in 'man-made' hazards. **It is therefore essential to understand the environmental root causes of risk in a given area and ensure sound land, water and natural resource use policies, ensuring that ecosystem services are sustained.** Simultaneously, the conservation, restoration and improved management of ecosystems and natural resources should rank high in risk reduction and climate change adaption planning and strategies.

- It is vital to understand how areas within the wider landscape are spatially connected (upstream and downstream linkages in a river basin for example), and how interventions in one area may have (positive or negative) implications for an area elsewhere, sometimes hundreds of kilometres away. **Risk reduction measures should therefore be planned at multiple spatial scales** – locally at the community level, but also across wider areas (river basins, deltas), and where relevant at transboundary levels. This calls for (regional) cooperation, but also for the capacity building of local communities so that they can join forces and work together on disaster risk reduction across landscapes.

- **The design and implementation of ecosystem-inclusive risk reduction measures requires collaboration with multiple sectors.** It for instance requires collaboration with engineers and land-use planners to ensure the integration of wetlands management and restoration in large-scale infrastructural/development approaches for disaster risk reduction. It is also essential to work together with development organisations and local communities to ensure integration of ecosystem management and restoration in (small-scale) community-based risk reduction initiatives, linking environmental, humanitarian and development approaches. Ecosystem-based approaches to reduce disaster risk need to be implemented alongside other measure of risk reduction, including avoidance of high risk zones, building codes, early warning and evacuation procedures.

Chapter 1: How Wetlands Can Help Reduce Disaster Risk

Damaged ecosystems are the hidden hand behind many supposedly natural disasters. They can be what turns extreme weather into human calamity. Degraded wetlands in particular can exacerbate floods, storms and droughts. Mangroves removed from coastlines leave the way open for cyclones and storm surges to rampage inland. Drained marshes and embankments that cut rivers off from their floodplains leave water coming downstream after heavy rains with nowhere to go – except to find the weakest point in flood defences and unleash disaster there.

This is a growing problem. The loss of forests, drainage of wetlands, silted up lakes and other damage to ecosystems is making many rivers more "flashy" – prone to periods with more intense flow but also to more low flows. Many of the worst effects are experienced in the densely populated, low-lying coastal regions of the world. They face more intense rainfall, more rapid run-off, rising tides, accelerating coastal erosion and worsening cyclones, while equipped with landscapes less and less able to absorb the impacts of these multiple threats.

Their ecological resilience is shot, and that is doubly bad news for their inhabitants. Many communities are being made more vulnerable to extreme weather – pushed into living in marginal and exposed environments at risk of floods, storms and droughts. All too often, their lives and livelihoods are shattered by extreme events that wipe out hard-won gains in poverty reduction.

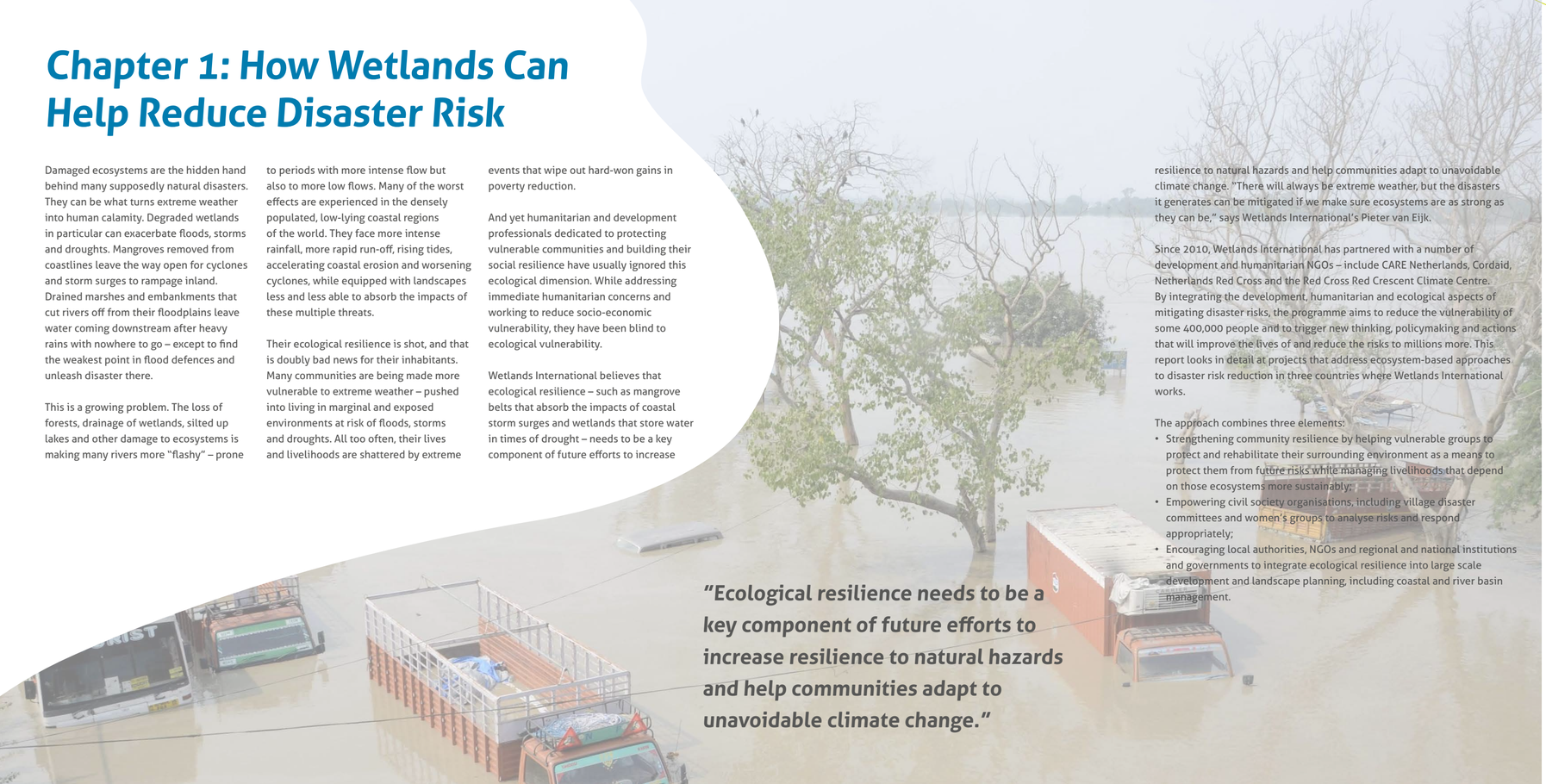
And yet humanitarian and development professionals dedicated to protecting vulnerable communities and building their social resilience have usually ignored this ecological dimension. While addressing immediate humanitarian concerns and working to reduce socio-economic vulnerability, they have been blind to ecological vulnerability.

Wetlands International believes that ecological resilience – such as mangrove belts that absorb the impacts of coastal storm surges and wetlands that store water in times of drought – needs to be a key component of future efforts to increase resilience to natural hazards and help communities adapt to unavoidable climate change. "There will always be extreme weather, but the disasters it generates can be mitigated if we make sure ecosystems are as strong as they can be," says Wetlands International's Pieter van Eijk.

Since 2010, Wetlands International has partnered with a number of development and humanitarian NGOs – include CARE Netherlands, Cordaid, Netherlands Red Cross and the Red Cross Red Crescent Climate Centre. By integrating the development, humanitarian and ecological aspects of mitigating disaster risks, the programme aims to reduce the vulnerability of some 400,000 people and to trigger new thinking, policymaking and actions that will improve the lives of and reduce the risks to millions more. This report looks in detail at projects that address ecosystem-based approaches to disaster risk reduction in three countries where Wetlands International works.

The approach combines three elements:

- Strengthening community resilience by helping vulnerable groups to protect and rehabilitate their surrounding environment as a means to protect them from future risks while managing livelihoods that depend on those ecosystems more sustainably;
- Empowering civil society organisations, including village disaster committees and women's groups to analyse risks and respond appropriately;
- Encouraging local authorities, NGOs and regional and national institutions and governments to integrate ecological resilience into large scale development and landscape planning, including coastal and river basin management.



"Ecological resilience needs to be a key component of future efforts to increase resilience to natural hazards and help communities adapt to unavoidable climate change."

SILTED UP SWAMPS IN THE PHILIPPINES

Deforestation on the uplands of Philippine islands has been causing soil loss, landslides and flooding downstream for decades. On Mindanao, the country's second largest island, Wetlands International and its partners are attempting to help communities in harm's way to revitalise their ecosystems and their safety. The focus of attention is the River Agusan, the Philippines' third longest river, which drains the island's northeast highlands.

As the river flows out of the highlands, it slows its flow and spreads out to form the Agusan freshwater swamp. This peat wetland, with a wildlife reserve at its core, covers around 200 square kilometres. It is rich in bird life and famous for the world's largest crocodile, which lives here, albeit it now in small numbers (less than 50). It is recognised under the Ramsar Convention as a wetland of international importance.

The swamp has long acted as a flood retention reservoir, protecting downstream communities by absorbing high river flows during heavy rains. But deforestation and soil erosion from mining and logging operations upstream is gradually filling the swamp with silt. So its capacity to moderate floods is declining. Tens of thousands of people in the river valley now suffer regularly from floods that can last for up to three months and result in flood waters up to three metres deep coursing through streets and homes. During storms in January 2014, more than 30,000 people were evacuated from 44 villages downstream of the swamp.

For years, humanitarian organisations have tried to assist victims of flooding and landslide tragedies in the Philippines. But relief aid, preparations for evacuation and ad hoc solutions like building houses on stilts have all failed to stem the destruction because the root cause, deforestation, has not been addressed. While loggers and miners remain at work in the headwaters of the river, the floods seem likely to keep coming. Only ecosystem-based solutions hold out hope for a long-term solution.

Wetlands International is attempting to build the case for action to stem the ecological destruction upstream, in order to revive the swamp and protect those living downstream. It will take time, but they are working with local communities and administrators to bring ecological thinking into planning, including reforestation and terracing on hillsides to reduce erosion. The governor of Agusan del Sur province has organised workshops with local government authorities to encourage them to work on protecting river banks from erosion and reforesting uplands.

The province now encourages local governement authorities to work protecting river banks from erosion and on restoring uplands.

The river used to flow all year round, but in recent years it has faltered. Water now fails to reach the swamp for around 100 days in a typical year.

LINKING UPSTREAM AND DOWNSTREAM COMMUNITIES IN KENYA

As demand for water grows in river basins, downstream users often suffer. This is especially true when those users depend on rivers and natural wetlands, which many still regard as "wasted" water. That is the case on the river Ewaso Ngiro in Kenya, which drains from the glaciers of Mount Kenya through the heavily populated agricultural region of Laikipia in central Kenya, to the Lorian Swamp in the arid northeast.

The 2300 square kilometre Lorian Swamp is an oasis for people and their animals in the dry season. Pastoralists depend on it and the river's floodplain for grazing. The river used to flow all year round, but in recent years it has faltered. Once permanent, it has become a seasonal river. Water now fails to reach the swamp for 100 days in a typical year. This threatens both pastoralists and the wildlife of the swamp, including birds and a large crocodile population.

The river faces several threats: abstraction for irrigated agriculture, including intensive horticulture in Laikipia, increased pressure from tourist lodges and deforestation along its course, which reduces the basin's ability to store water. So, despite drying up much more than in the past, it also suffers occasional intense flash floods. Climate change may also play a role in the changing hydrology. A further potential threat is the planned construction of a new 100 million US water supply dam on the river at Crocodile Jaws near Oldonyiro.

Wetlands International, the Kenya Red Cross and Cordaid's local partners are helping communities adapt against the changing river flows and its impact on the floodplain and the Lorian Swamp. Conventional community risk reduction does not address the ecosystem threat from upstream. So Wetlands International and its partners have encouraged 50 downstream communities to organise themselves in the Waso River Users Empowerment Platform. The network has empowered them to link up with stakeholders further upstream, both to rethink the river's development and use, and to share information about river flows and early warning about floods coming downstream.

In both 2013 and 2014 the platform grabbed national attention when they organised Camel Caravans with local water users from the Samburu, Turkana, Gabra and Borana pastoral communities. Caravans travelled both upstream and downstream, and met in the middle of the river Ewaso Ngiro. This galvanised the attention of communities and attracted national media coverage that put pressure on the government, local authorities and private sector. A subsequent conference with all the stakeholders resulted in commitments to support local organisations in order to protect and restore the river and reduce abstractions.

Downstream communities are now organising themselves to link up with stakeholders upstream to rethink the river's development and share information about river flows and floods coming downstream.

Chapter 2: Living with floods in the Mahanadi Delta, India

In October 2013, one of the fiercest cyclones to hit the Bay of Bengal for many years made landfall on the low-lying delta coast of the Indian state of Odisha. With winds battering the coastline at more than 200 kilometres per hour, the structural damage from cyclone Phailin was intense. Thousands of straw, timber and bamboo homes were destroyed across the delta of the River Mahanadi, one of India's largest deltas. Trees were uprooted, cars upturned and power lines broken across the delta as high winds were accompanied by a three-metre storm surge.

Memories were stirred of the last "super-cyclone" Kalinga, which hit the same area in 1999 and claimed more than 10,000 lives. And yet this time it was different. When the winds were stilled, a million people were safely in shelters, with only 59 deaths reported.

One reason was the work of Wetlands International, CARITAS India and their local partner organisations. When I visited six months later, villagers spoke of how they had been trained to establish disaster committees, set up family survival kits, and develop escape plans to reach government shelters. When they returned to their villages after the cyclone, many could call on grain banks they had built up, a handful of rice grains and black gram lentils at a time, over the preceding months. And, thanks to the alliance's schemes, more than 700 toilets and 300 hand pumps had been raised on concrete platforms to keep them clear of flood waters.

It was a success for humanitarian action and social resilience. But while lives had been saved, much of the natural infrastructure that helped protect communities against cyclones and storm surges from the ocean had been badly damaged. Along much of the delta's 200 kilometre coastline, mangroves were uprooted, and shelter-belt forests planted on dunes to take the force of the storm and surges were buried in sand.

And there was more to come. The cyclone had dumped heavy rains across the whole catchment of the River Mahanadi, an area the size of England and extending far inland from the delta. Soon that rain was swelling the river – and heading for the low-lying delta. As the Indian Express put it a month later, "just as the people were congratulating themselves for surviving the cyclone, they were hit by a wave of flooding that few had bargained for."

Within two days, the rivers flooded large parts of the delta. More trees were washed away. Embankments designed to prevent floodwaters covering the land, came under siege. The highest banks simply channelled the water into ever higher and faster flows towards the lower banks, which were overwhelmed. Once inside the banks, the water was trapped on waterlogged fields, inundating schools and homes, smearing paddy fields with mud and sand. A month later there was still devastation.

So with lives protected, here is the new problem: how to save livelihoods and revive vital ecosystems. The events after Phailin emphasised dramatically the reason that ecosystem management is such a central element in the work programme of Wetlands International and its partners; without attention to ecosystems and livelihoods, disaster protection will not work.

> *The Indian Expresss:*
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> "Just as the people were congratulating themselves for surviving the cyclone, they were hit by a wave of flooding that few had bargained for."

Wetlands International and its partners are working in a total of 184 villages in both the Mahanadi delta and the Ganges floodplain in Bihar to the north. Much has been done since the programme got underway on the delta in 2011. To help make livelihoods more disaster-proof, staff distributed flood-resistant rice varieties to most of the villages where it worked, helped 25 villages restore ponds to store water, and stocked many of them with fingerlings. Villagers received training in fish farming and growing vegetables, and help in re-establishing plantations of betel vines, a valuable local cash crop.

To bolster environmental resilience against floods, the alliance network helped delta people in 69 villages plant 140,000 saplings to stabilise river banks and coastal defences. In places, silted up rivers were dredged.

But there is a limit to what individual villages can achieve, said Ritesh Kumar, conservation programme manager of Wetlands International South Asia. While they can provide some protection by reviving ecosystems within their borders, none of this will ultimately work unless the delta landscape as a whole is right. And right now there is a great deal wrong. He believes that villages need to band together to address inter-village issues and to lobby governments for protection against bigger forces that exacerbate coastal erosion, increase flood flows coming down the river into the delta and restrict the delta's ability to absorb floods from either land or sea.

Wetlands International, in partnership with government bodies such as the Integrated Coastal Zone Management Programme (ICZMP), is exploring how landscapes can be managed and enhanced in ways that provide both economic development and security from disaster.

Severe storms appear to be becoming more frequent in the Bay of Bengal. During the 1960s there were only three flood events on the Mahanadi delta; in the first decade of the new century there were seven. But the problem is not just climate change; it is at least as much due to changing land use.

Since 1975, a third of the delta's wetlands have been lost to farm drainage schemes, ports, industrial plants and prawn farms. Wetlands once absorbed excess flow, while mangroves on the coast absorbed some of the tidal and wind force of cyclones. But the water, whether from storm surges or river floods, has to go somewhere. And all too often, the water has ended up trapped behind embankments in stagnant and waterlogged fields.

"We need to rethink embankments. While they can provide local protection, they add to wider risk, because flood flows become concentrated - bursting through defences at the weakest point."

Some measures make obvious sense. The ICZMP has an office on the Mahanadi delta and wants mangroves on the banks of all tidally-influenced rivers, creeks and mudflats along the delta coast. But, says Kumar, it is also vital to rethink how water on the delta itself is managed.

"Until two centuries or so ago, people were aligned to the floods in the way they used the area, with fishing and flood recession agriculture. But British engineers decided to increase rice production by managing the flood. It worked up to a point. But it reduced the resilience of the system."

Communities that once lived with floods, benefitting from the fertile silt that they distributed across the delta, now live behind embankments. They are dependent on artificial fertiliser to replace the silt, and are increasingly vulnerable to major floods that can breach the defences. "All this increases disaster risk," Kumar says. "We can't go back, but we do need to introduce elements of the old regime. Living with floods is the key." The result will usually be soft engineering, which nurtures rather than confronts natural processes. Floods must be given somewhere to go.

"We need to rethink embankments," says Kumar. While they can provide local protection, they add to wider risk, because they restrict the ability of floods to spread across the land. Instead flood flows become concentrated – bursting through defences at the weakest point.

This landscape-level approach creates problems for agencies trying to encourage community-based solutions for problems like flooding; collective protection cannot always be achieved simply by scaling up successful examples of protecting individual communities. "Working at the community level is not enough to reduce risk. Ecosystems work at a higher level. Scale is critical," says Pieter van Eijk of Wetlands International. The danger is that villages might end up in a destructive race for better protection, in which each individual village's gain damages other villages.

One way to encourage villages to think beyond their immediate vicinity is by linking up those with common problems, says Kumar. Most coastal villages on the delta, for instance, face the constant barrage of the ocean, cyclones and often coastal erosion and saline intrusion of freshwater aquifers. Working together they can avoid conflicts over embankments, and organise projects with collective benefits like setting up drainage systems to relieve waterlogged areas, organising dredging of silted rivers and planting shelter belts. In the central delta, villagers also face common risks from floods and waterlogging, while upstream villages at the head of the delta are confronted with droughts as well as floods.

Land use changes across the Mahanadi catchment are speeding the flow of rainwater into the river, and hence to the delta. This can be a problem even when there are no cyclones.

But there are other issues that must be addressed if these landscape-level problems are to be resolved. Many of these will require advocacy work with governments and sometimes corporations.

Along the delta coast, industrial developments such as iron and steel, cement, paper, fertiliser and power plants threaten coastal ecosystems such as mangroves and shelter belts through pollution, logging and cutting off fresh water inflows. And dredging to allow access for ships is changing coastal processes of erosion and deposition. Often, dredging increases the ability of ocean currents to erode unprotected coastline. The delta port at Pradeep alone dredges some two million cubic metres of sand and silt a year. The result, says the ICZMP, are coastal erosion rates of up to 100 metres a year in places.

Changes upstream also pose new risks to those living on the delta. Land use changes across the Mahanadi catchment are speeding the flow of rainwater into the river, and hence to the delta. This can be a problem even when there are no cyclones. A critical element here is the management of large dams able to control the flow of water downstream to the delta.

The Mahanadi flow is controlled by the Hirakud dam. Though completed by post-independence India, the dam was commissioned by a British governor, Sir Hawthorne Lewis, who promised in 1946, as he laid the foundation stone, that it would provide a "permanent solution" to floods on the Mahanadi delta.

That never happened, in part because the dam has other purposes too – to generate hydroelectricity and ensure a supply of water for irrigation schemes. But these needs encourage the dam's managers to keep the reservoir as full as possible, whereas flood protection requires keeping the reservoir as empty as possible, reserving space to capture flood waters.

Since Hirakud's completion, floods have increased rather than being banished. It is true, says Kumar, that much of the flooding on the delta is caused by rainfall on the delta itself. But at times of very heavy rain, it can be exacerbated by rushed releases from the dam, sometimes required to prevent it from being damaged. Rather than increasing the resilience of delta communities, the operation of the dam leaves them more vulnerable than before to the most extreme flood events.

The task of finding landscape solutions to flooding and other disaster risks on the Mahanadi delta is clearly beyond the reach of the programme itself. But Wetlands International South Asia is working with the ICZMP and the Odisha State Wetland Management Authority to change the management regimes of both the Hirakud dam and the Rengali dam, on the River Brahmani, to address the water needs of downstream ecosystems and reduce disaster risks for delta communities.

Rather than increasing the resilience of delta communities, the operation of the dam leaves them more vulnerable than before to the most extreme flood events.

Kumar's hope is that the discussion that Wetlands International and its partners are promoting about how the management of ecosystems and rivers can reduce risks will generate a wider debate to increase community resilience to disasters and climate change, including rising sea levels. Only integrated thinking about delta processes can once again make floods a source of resilience and prosperity. Cyclone shelters can save lives, but not livelihoods.

Map of village developed for disaster preparation, India

BHUTAPADA

Bhutapada is close to the coast on the Mahanadi delta. Its inhabitants pride themselves on being very organised. They have painted a big sign at the roadside so you know when you get there. And a wall in the centre of the village has a large map showing every one of its 114 households, as well as emergency phone numbers in case disaster strikes.

But it is also poor, with most landholdings measuring less than a hectare. And it is very vulnerable to floods. The village is trapped between the ever-present risk of cyclones and storm surges coming in off the nearby Bay of Bengal, and rising river flows coming downstream onto the delta.

The river embankments, which once protected the village, can now be a curse. Once the water comes over the top, it has no means of escape.

Since 2011, when Bhutapada became one of the pilot villages of working with Wetlands International and its partners, the villagers have drawn up their own disaster plan. Every family has a survival kit; the school doubles as a cyclone shelter; and the village women's self-help group maintains an emergency grain bank, its drums topped up weekly with a handful of rice from every household. When cyclone Phailin swept through in late 2013, no lives were lost here, said Banita Behera, president of the self-help group. "And when we returned to our houses, the grain bank provided food for the entire village."

So far, so good. But Alok Mallick, secretary of the village disaster committee, wanted to show me the obstacles they face. He took me on a walk to the River Dhauna on the edge of the village. The embankments on either side of the river are high. But not high enough, he said. Every year, they are overtopped. Standing on top of the bank, he pointed to his chest. "In the floods, the water comes this high; it floods all across our land, right to the next village."

The river embankments, which once protected the village, can now be a curse. Once the water comes over the top, it has no means of escape. The banks prevent the water from returning to the river. After Phailin, the village stayed flooded and its fields remained waterlogged long after the water level in the river had returned to normal, he said. Crops were lost.

How do the villagers cope with this unexpected vulnerability? The disaster plan developed under the programme aims, among other things, to help villagers diversify their incomes. With assistance in providing seeds, saplings and training, they have been growing more coconuts, and planting vegetables such as brinjal, potatoes and onions for the first time – mostly for sale in local markets.

Only by bringing villagers together to manage their common problems can they hope to stem the damage from brutal floods that wash across their land most years.

The villagers showed me a fish pond by the road at the entrance to the village. Thanks to Wetlands International and its partners, it had been stocked with 2000 fingerlings the previous year. They ran a net through the water to show me the fish were growing well, before putting them back so they could grow some more. The villagers had plans to turn an old stagnant pond into a second fish farm. The programme has also helped protect vital village infrastructure by raising its borehole and sanitation block onto concrete platforms, clear of most floods.

But the villagers also want better natural protection against floods. They have planted some 5000 acacia and other trees on the river embankments and land around the village, and have plans to plant 20,000 more. They hope the deep roots will stabilise the banks and prevent floods from washing away their fields.

They know that the erosion adds to the already heavy silt load in the river. That silt is clogging up the nearby river mouth, causing water to back up and worsen flooding in the village. "This year, we will be desilting the mouth," they said.

But no village can insulate itself from the wider forces at work on the delta – forces that are often increasing disaster risks for everyone. The people of Bhutapada told me regretfully that they had a problem with their neighbours. "One reason the floods are getting worse," said village elder Ramesh Mallick, "is that other villages are building boundary banks that try to protect the whole village and its farmland." But the water has to go somewhere. The banks that keep one village dry raise water levels outside and make life worse for the rest, he said.

Might Bhutapada try to create its own village boundary bank? It could come to that, Mallick said. But if every village did it, then nobody would gain.

The case illustrated well Kumar's point that only by bringing villagers together to manage their common problems can they hope to stem the damage from brutal floods that wash across their land most years. Most interestingly, the answers to my questions at the village meeting in Bhutapada showed that the case for collective action is getting across to poor villagers. They understand their predicament only too well.

Sanapatna cyclone shelter, India

SANAPATNA

Sanapatna is more exposed to the elements than most coastal villages on the Mahanadi delta. The community of some 2000 people, mostly fishers, is surrounded by water. It is perched on a sand spit between Lake Chilika, the largest coastal lagoon on the east coast of India, and the Bay of Bengal.

Nobody died in the village when Phailin made landfall barely 50 kilometres from here in 2013. That was a triumph. But the damage to their village and livelihoods was extensive.

Six months later, Wetlands International and Netcoast, a network of local NGOs helping coastal communities on the delta to fend off disasters, were working to bring Sanapatana back from the brink. This included helping them coordinate the work of other foreign donors eager to build infrastructure. Driving into the village, I saw mechanical diggers from the state water department rebuilding the village's flood defences on the lakeshore.

But the task was huge, said villagers I met upstairs in the cyclone shelter. Many houses in the village were still uninhabitable. Worse, they had lost many of their fishing grounds – probably forever. The cyclone had burst through the sand spit near the village and moved the lake's main exit to the sea. Before Phailin, the main channel to the sea passed in front of the village. It contained a good brackish-water fishery that was the main business of the village. Now the channel was 10 kilometres away and the fishery was gone due to the loss of brackish water.

> The village's income from fishing has fallen by 70 percent since Phailin. A quarter of the men have left the village to find work.

The village's income from fishing has fallen by 70 percent since Phailin, said Harihar Chelbera, the secretary of the disaster committee. "A quarter of the men have left the village to find work." Some were going to Chennai, a thousand kilometres south. Gurama Behera, a member of the women's village self-help group, said the women had many fewer fish to sell in the market at Puri 40 kilometres away. They were forced to find work as domestic drudges in nearby villages.

Their main hope for the future was tourism. The ICZMP is building a jetty close by, where the village hopes that the small tourist boats that ply Lake Chilika would soon be tying up. But meanwhile, fearing the waters will encroach further, the villagers have identified 25 hectares of empty land on slightly higher ground to the west that they want to annexe as an emergency retreat.

They were not without hope. But, as they described their plans, it was clear they faced a big obstacle. The village had been here on the edge of the lake for several generations. But as migrant fishers, they didn't have legal title to the land on which they lived, still less to the land they want to move to. "We want legal ownership," said Chelbera. "If we had had that, we would have got compensation for the houses we lost in the cyclone. Because we didn't we got nothing."

They knew that however much they and their backers at Wetlands International and its partners invested in saving their community, it could be lost overnight. It wasn't just the elements that were against them; it was the law too.

TANDAHAR AND KEUTAJANGA

The villages of Tandahar and Keutajanga sit at either side of the mouth of the River Keluni, one of the delta "distributary" rivers that distribute the flow of the Mahanadi. Water is threatening the villages from all sides – from the increasingly silted up river, and from the ocean, which comes closer every year thanks to rapid coastal erosion.

> Water is threatening the villages from all sides – from the increasingly silted up river, and from the ocean, which comes closer every year thanks to rapid coastal erosion.

The sand dunes behind Tandahar once provided ample protection from ocean surges. But, despite being planted with a shelter belt of trees, the dunes are disappearing fast. "The sea is coming ever closer," said the secretary of the disaster committee, Pramod Swain. "Our fathers' land is now under the water. In 50 years it has come in about 1.5 kilometres."

When he was young, Swain said, "you could walk 20 minutes through the trees to the sea. But now the trees are almost gone." The pace of loss has accelerated in recent years, despite community planting of trees on the dunes.

"Maybe the sea erosion will take our village," the women said when I asked them to imagine the village in 30 years' time. "Our land is very limited. Some better-off families have bought land in safer places so they will have somewhere to go."

But most were determined to fight to protect their land. Village women have formed a forest protection committee to look after the remaining trees and plant more. They have imposed a 50-rupee fine for anyone cutting branches or letting their livestock into the shelter belt. Wetlands International and its partners are improving lives in this vulnerable environment in several ways. As in many villages, training in aquaculture and growing vegetables is popular, for improving both village diets and village income. More than anything, perhaps, it was a sign that the outside world had confidence in their ability to survive. It gave them confidence, too.

In recent years, Tandahar has had a growing problem with the mouth of the River Keluni silting up. Unable to escape to the ocean, river waters spread right into the village. "The river mouth got completely closed at times, flooding our fields," said Prabull Rout, secretary of the Tandahar disaster committee. After Phailin, the sea water was gone within hours, but the river water took nine days to go.

Other villages upstream were hit too. In 2012, the villages assembled a group of labourers to dig out the silt. After the story of their efforts got in the local media, the state government lent its heavy equipment to do further dredging.

But the following year, the people of the neighbouring village of Keutajanga, on the other side of the river mouth, had a nasty shock. Storm waters during cyclone Mahasen in May 2013 eroded a sea wall at the outer extremity of the river mouth, just past the area dredged by the people of Tandahar. As the wall gave way, some 40 hectares of farmland were inundated.

> Dredging of river mouths exacerbates coastal erosion along parts of the delta coast.

In April this year, workers were rebuilding Kuetajanga's sea defences, before the next cyclone season. But the question arose: were the dredging and the destruction of the sea wall linked? British geomorphologist John Pethick, adviser of coastal defences to both the World Bank and Odisha government, says dredging of river mouths exacerbates coastal erosion along parts of the delta coast. And both the timing and the close proximity of the two events here were worrying. But, says Kumar, nobody can say for sure.

Undaunted, the people of Kuetajanga are fighting against the elements, with assistance from Wetlands International and its partners. Ashok Biswal proudly showed off his quarter-hectare thicket of betel vines, surrounded by bamboo frames to protect them against the wind. The stand, along with a number of others between the village and the shore, had been planted since Phailin, with assistance from the programme. Biswal looked forward to a net annual profit of 20,000 rupees ($200). Even closer to the shore, they were planting mangroves and a shelter belt of trees. Nobody was giving up here.

Tandahar village meeting, India

Chapter 3: Sustaining Mali's Inner Niger Delta

The Inner Niger Delta in central Mali is a giant green oasis on the edge of the Sahara desert. It is one of the country's most productive areas, but also among its poorest. At the height of the wet season, when the River Niger is swollen by heavy rainfall in Guinea, an area the size of Belgium, from Mopti to Tombouctou, turns into a landscape of lakes. As I discovered on a previous visit in January, travel is by boat, across a waterscape of fishing vessels and migrant birds from Europe, feasting on the abundant aquatic life. But once the waters start to recede, farmers move in to plant rice, millet and other crops in the wet mud. And Fulani cattle herders bring their animals to feed on the rich hippo grasses, known locally as bourgou, that are exposed by the retreating water. By May, the lakes are dry and their beds turned to scrubby woodland, dry pasture and desert. Outside the villages, people are rare. Travel now is by four-wheel drive across dried up lake beds.

It is in this environment of extremes that Wetlands International and CARE Netherlands, with the technical expertise of the Red Cross Red Crescent Climate Centre are working with local NGO partners, AMPRODE-Sahel, ODI-Sahel and GRAT, to improve the resilience of communities by protecting and rehabilitating the ecosystems on which they depend. This involves helping them to plant and rehabilitate flooded forests and the bourgou grasses that serve as both fish nurseries and livestock fodder, to reduce grazing pressure on trees and grasses, and to manage water in ways that can sustain those ecosystems and the livelihoods of the communities.

In return for working on these long-term ecological projects, Wetlands International and its partners offers communities assistance with projects that deliver more immediate benefits to livelihoods, like setting up vegetable gardens and planting fruit trees. Often this is done by establishing micro-credit schemes for women's groups.

The programme in Mali targets those most in need. The government has listed 703 vulnerable municipalities. The highest concentration is around the Inner Niger Delta, where all 20 of the programme's project villages are situated. Within these municipalities, mayors and other local officials choose which communities might benefit the most by participating.

Daouda Sanankoua, the mayor of Deboye municipality, said: "I don't just choose on the basis of the government's vulnerability index. I also see which can benefit from help. Some will always fail. We like the villages that are doing things for themselves." Good leadership was important too, he said. "Many villages work hard, but it is important that they work together."

Wetlands International and its partners then hold village meetings to set an agenda. In each village, a disasters committee is established to handle projects, make decisions and liaise with local officials and NGOs.

> *"The floods in the delta are likely to be poor. So soon we will be advising the rice farmers to plant drought-resistant varieties."*

An important part of the project has been to help communities learn how to make better sense of their environment using modern tools. Many have been given rain gauges and help in using the data from them to decide which crops to plant. Soon Wetlands International hopes to be linking up with a mobile phone company to send text messages to villages warning them of upcoming flood or drought risks.

As we travelled into the delta in May 2014, Wetlands International's Mali director Bakary Kone noted that: "Rainfall has been poor in Guinea this year. The floods in the delta are likely to be poor. So soon we will be advising the rice farmers to plant drought-resistant varieties."

People I met in pilot villages were all keen to adopt new ideas. Many communities were developing their own strategies to adapt, usually through more sophisticated management of their natural environment, such as channelling water into fish ponds and onto grazing pastures. In some cases, the programme simply helps them do what they already plan – by providing finance or technical expertise.

> *"We think upstream dams are preventing the water from coming into the delta. We are worried. There are two more dams planned."*

They were also well aware that ecosystem management in their villages, while valuable in the short term, had its limits. Environmental forces outside the wetland were shaping their world, and threatening their traditional ways.

Climate was changing. I asked several communities about the climate change they were seeing. At Sobé on the north shore of Lake Deboye in the heart of the delta, they reported classic signs of desertification. "The wind is driving the sand into the village," said village leader Samba Touré. "Most of our fields are gone now. The school is next."

In Noga village, the women discussed the question for some time. "There are three things," their spokeswoman finally concluded. "One is we are getting less rainfall because of lack of trees in the area. Second there are big winds here, which means sand dunes are invading our fields. And third, the water flows in the rivers are becoming weaker. We think upstream dams are preventing the water from coming into the delta. We are worried. There are two more dams planned."

Sanankoua, who travelled with me to several villages in his area, said: "Everything here depends on the water, but the government is taking our water. They are giving it to foreign farmers. The lakes don't fill properly now."

Wetlands International is involved in advocacy work to raise the profile of the Inner Niger Delta and its ecosystems and inhabitants. It commissioned a hydrological analysis to make the case for maintaining river flows into the delta, and has encouraged local mayors and other leaders to make the case too.

This is necessary work. For some in government, the delta remains a remote place where the tarmac roads turn into rutted tracks and ways of life seem remote from modern Mali. They remain unconvinced that protecting water flows into the delta is an effective use of a vital natural resource. They think it is a good idea to hold back flood flows to generate hydroelectricity and fill irrigation canals.

But, says Kone, the delta is responsible for 8 per cent of Mali's GDP and is home to a third of its cattle – some two million animals in all – as well as three million sheep and goats. Fish from the delta are exported all across West Africa. I saw trucks in the major wetland market in Mopti loaded up with fish packed in crates with ice to the make a week-long journey to northern Nigeria.

The maintenance of ecosystem services on the wetland, which sustain two million people and deliver major gains to the national economy, can only be achieved if the water keeps coming down the river. Wetlands are nothing without water.

SIMINA AND NOGA

Nobody quite knows why the village of Simina suddenly began flooding. The village, which is just off the edge of the Dogon plateau in Mali, had been there for 400 years without trouble, said Youssef Traoré, the village secretary. But since the 1980s, water has been cascading off the surrounding hills and converging on their homes. One theory is that the death of many local trees during the drought back then had led to more flash flooding. But Traoré said villagers blamed construction of a paved road close by at around the same time. It may have changed drainage patterns. Together with the increase in flood risk, the village has also been suffering from increased drought vulnerability.

Either way, things had got so bad that district officials in nearby Konna said the only option was to move the entire community of 300 people. But the villagers thought differently. They agreed upon a 'hybrid' approach that would yield increased security from flooding but also provide enhanced resilience to drought. They decided to dig a dyke to protect their homes, while channelling the flood water to a depression close by. Once collected, the water could nurture a seasonal fishery, while providing a reservoir for cattle and farming.

So two years ago, they got out their shovels. Every family was given a stretch to dig. The men dug the channel and the women piled the earth to create the dyke on the village side. It took them 25 days to complete the 1.3 kilometre structure. It worked. "In the last two years the floods have stopped reaching the village," Traoré said.

This was all done on their own initiative. But now Wetlands International and its partners are helping the villagers to become more resilient to the climatic extremes by improving their use of the water. They have supported the village in raising the dyke further and stabilising it with grass. To counter dry periods they are helping the village with new drought-tolerant seeds, and rain gauges to help farmers decide when to plant them.

"The dyke is our future," said Trouré. "Without it, future generations will move away and the village will die. With it, we have a secure future." He admitted that many of their youth still go away to work in distant goldfields in the west of Mali when there is not much to do on the land. "But they will return if they have somewhere to come back to."

Nowadays many of these natural water storage structures are dry. They are cut off from the main river by siltation, in turn driven by deforestation and erosion and the reduced self-cleaning capacity of the delta due to upstream water abstractions.

Digging channels to collect water is becoming a way of life for many communities on the delta. Water is abundant for a few months of the year, but its abrupt disappearance is a huge constraint on agriculture the rest of the time. In the past water would have been stored after the floods in ponds and lakes. Nowadays many of these natural water storage structures are dry. They are cut off from the main river by siltation, in turn driven by deforestation and erosion and the reduced self-cleaning capacity of the delta due to upstream water abstractions.

Take Noga, in the municipality of Dialloube. Reaching the village takes hours of driving across what is, for much of the year, the dried bed of a huge lake. Forty years ago, people in this village could rely on the flood. Now, managing water is a major task of the village disaster committee.

They are lucky in that one of the main rivers of the delta, the Mayo, flows right past the village. But it is dry for much of the year. And these days, even in the rainy season, it rarely reaches the top of its bank. It no longer flows onto the village's farms and grazing land, which it once watered and covered with rich silt. The villagers have decided to change that.

They took me to see a breach in the river bank that they had recently dug to allow water to flow onto the flat lands behind. Then, driving through stands of mimosa bushes, we followed the route the water would take in a couple of months' time. It would pour from one excavated depression down an enlarged channel into the next depression and so on through a cascade of five ponds, the biggest covering more than 20 hectares. The channels had been dug by villagers, but with hydrological expertise from Wetlands International.

"The ponds should flood for five months, between August and December," said Baba Troulet, the village secretary. "They will be full of fish, as well as birds like egrets and herons, and grasses that the fish eat. They will overflow into the bush so we will have more pasture." Six local villages stand to benefit from the scheme. "The ponds will be a big opportunity, both against poverty here and as a way of adapting to climate change," said villagers at a meeting back in the shade.

The villagers, like most in the area, are poor and marginalised. Like many villages in the delta, Noga has no school. Only one child from the entire village was in education – at a village 10 kilometres away. But their channel project showed they did not lack initiative.

Other villages I visited had also struck out on their own to manage water. The people of Kakagna have dug a 300-metre channel to direct water from the River Niger into ponds where they grow fish. Every year, as the dry season approaches, they dredge the year's accumulation of silt to keep the channel wet through the dry season and allow fish to migrate in and out.

In Sobé, the men proudly showed me an 800-metre irrigation channel they had just dug from the river to 40 hectares of fields where they planned to grow rice. It was a major undertaking, completed entirely by hand over a few weeks. But they were struggling to raise the cash to pay off the bill for a pump to get the water into the channel during the dry months. "We owe 7 million West African francs (CFA)," they said. That's $15,000.

Kone said Wetlands International and its partners might be able to help find potential donors to finance the pump, and also with expertise. "We are already helping another village, Tomina in Sofare district, which is doing something similar." After our journey, Kone arranged an exchange visit between the two villages so Sobé could learn from the experiences of Tomina.

"We think climate change is a reality. We see it ourselves, and we decided we should be prepared."

I asked the villagers of Sobé why they thought such an ambitious project was necessary. They said they had seen how river waters no longer reached their fields naturally, and were determined to take charge of their destiny.

"We have been talking about climate change since we saw a video on the TV, produced by Wetlands International," village leader Samba Touré told me. "We think climate change is a reality. We see it ourselves, and we decided we should be prepared." Kone smiled. "That video is proving really effective," he said. "Many villages, even out here, have seen it."

Women's vegetable garden at Guidio in Mali

Both camps agreed that the vegetables were feeding families, while providing women with a valuable new source of income in local markets, and raising their status within the village.

VEGETABLE GARDENS

Vegetable gardens are one of the most successful interventions under the Mali programme. The gardens are especially important for women, who cannot traditionally own land in Mali but can assume "ownership" of their gardens. Almost every village involved in the project either has one or wants one. In Kakagna, they have two – since the village women have lately fallen into two competing camps. Now they vie for vegetable supremacy, competing to display their produce to visitors.

The frenzy of vegetable growing in Kakagna came about partly by accident, explained the president of the first women's group, Diko Bilakoro. The original proposal from Wetlands International and its local partner was to fence off an area of land to grow trees such as Acacia kirkii. But five years on, the trees were not doing well, because of termite attacks, while the women had filled the gaps by planting onions, lettuce, tomatoes, cabbage, okra and much else.

The key, Bilakoro explained, was the fence. It kept out livestock that would otherwise have eaten the vegetables. Behind the fence, the women were manuring and watering their tiny personal plots for all they were worth.

Not to be outdone, the second group banged their buckets loudly to greet our arrival. They showed off sorghum and cotton as well as mangoes and vegetables. Back at a village meeting, both camps agreed that the vegetables were feeding families, while providing women with a valuable new source of income in local markets, and raising their status within the village. "The men are happy too, because women now contribute two-thirds of the family income," Bilakoro said.

In Noga, 93 women produced around five tonnes of onions, okra, tomatoes, maize, rice and beans, from their one-hectare garden. Onions sell for about 500 CFA a kilogramme (about a dollar) in local markets. One woman said she had earned 10,000 CFA – enough to buy two sheep. There was only one downside, the men said with a smile. The garden had taken land they once played soccer on.

A couple of hours drive north across the dried Lake Debo is Guidio, another desperately poor delta village that is innovating to survive. At the end of the village they are extending the land raised above the lake floodplain with a constant supply of household trash. In front of almost every house sat a cheap bank of Chinese solar panels, bought in the Mopti market. By day the panels charged car batteries, which by night delivered power for TVs and household lighting.

Here the women were tending both a tree plantation and vegetable garden. Fatoumata Cisse, president of the women's group, showed me aubergines and onions, carrots and cotton, beetroot and cowpeas, guava and chilli peppers – and henna, which is used here as in Europe as a skin and hair dye. Then she grabbed some foliage from another bush. "This is our pharmacy," she said. "We give it to sick children."

"This isn't our project anymore," said the man from ODI-Sahel contentedly. "It's theirs. That's how it should be. It started with trees, but it's mostly vegetables now. We just came to check things were okay."

"Since we started to restore the bourgou fields, fishing has been good. We have fish to sell in the market all year now."

BOURGOU BEDS

If planting trees is essential to maintaining terrestrial ecosystems, then planting bourgou grass, also known as hippo grass, is essential to maintaining life in the seasonal lakes that form when the River Niger floods its inland delta. Bourgou beds are the nurseries for the delta's fisheries. More bourgou means more fish. And as the waters retreat, the aquatic pastures of bourgou also sustain cattle and goats brought by nomadic Fulani herders from as far away as Mauritania and Burkina Faso. Villagers eat it too, when their millet crops fail. They call it "starvation food". It tastes rather like couscous. It also ferments to make a popular sweet beer.

But the bourgou grasses are in trouble. As the delta lakes diminish, so are the bourgou pastures and with them the fisheries. So, a number of villages have begun planting and cultivating bourgou.

Outside Akka on the shores of Lake Debo, I saw a 30-hectare stand nurtured by villagers. It attracted so many fish that thousands of cormorants and pelicans gathered round. The villagers were content that the birds were feasting on their fish, however. They said that bird droppings fertilised the waters, encouraging the growth of bourgou, which brought more fish. "The more birds there are, the more fish we get," said Alpha Fofana, who was in charge of the planting project.

Nearby in Gouraou-Bozo, Wetlands International and its partners are encouraging locals to plant bourgou grasses in return for micro-credit for other small village projects. Villagers had planted 15 hectares of bourgou cuttings over two years. The second crop was just poking above the waters as our boat passed. The planting took place during a quiet period for fishing. "We used to migrate to find work when we hadn't much to do here," said Youssouf Kosibo, a member of the village committee.

"If they do more, they will get more micro-credit cash," said Kobe. But they don't need much incentive. The gains are clear to see. "Since we started to restore the bourgou fields, fishing has been good," said Kosibo. One of the older women, Koumba Moussa Kampo, agreed. They have fish to sell in the market all year now, she said, whether fresh from the lake between December and February, or dried or smoked at other times.

As soon as the water levels start to fall, Fulani cattle move in. But the fishers, who are from the Bozo clan, say they want to protect the grasses by keeping the cattle out. "We know the fish are bigger if we prevent livestock going into the grasses till later," said Kosibo. "We tell the herders they can only go when the big fish have been caught, which is in April." But they don't want to exclude the cattle altogether. The cattle help to propagate bourgou by trampling broken stems into the mud. Timing is everything.

Such disputes can cause conflict. But so far things have been amicable, said Kosibo. "Bozo and Fulani have lived together around Gouraou for centuries," he said. The land rights are well-established and nobody has broken ranks. And there is another incentive. Wetlands International and its partners will not fund projects where there are disputes over land, said Kone.

The bourgou grasses are in trouble. As the delta lakes diminish, so are the bourgou pastures and with them the fisheries.

Bourgou grass beds bring back the fish to the delta lakes, Mali

Women entrepreneurs in Kakagna, Mali

Many villages receive micro-credit in return for doing ecological restoration projects that help to sustain their livelihoods in the long run as well as guard against natural hazards and protect biodiversity in the delta.

MICROCREDIT

Many villages involved in the project have been offered micro-credit in return for doing ecological restoration projects that will help sustain their livelihoods in the long run as well as guard against natural hazards and protect biodiversity in the delta. Overall, the micro-credit scheme operated by Wetlands International to finance conservation, known as Bio-rights has allocated 60 million CFA in loans to women's groups in Mali villages.

The micro-credit schemes – run by specialist institutions like the Bamako-based CAMEC – differ in their rules, but the beneficiaries are mostly village women's groups. This is a deliberate policy, partly because women need support in traditionally patriarchal societies, partly because they are generally better at organising themselves and paying back loans, and partly because, as the members of the community who sell produce in the markets, they are more used to handling money.

Typically, the initial supply of cash credit is augmented by the women themselves, who top up the pot with a small subscription each week. Typically, the credit funds things like buying rice huskers, establishing grain banks, restoring and stocking fish ponds, and buying seeds for vegetable gardens. Typically, too, the women hold the cash in padlocked boxes, which they displayed proudly at the village meetings I attended.

In Kakagna, the village got credit in return for digging a channel that supplied water to a fish pond. The villagers used the cash to set up a grain bank to tide them over the "starvation time" at the start of the rainy season, before new crops have grown. At Gouraou-Bozo, women put in 125 CFA (about 25 cents) each week, of which up to 100 CFA was used as loans and 25 CFA was kept for social activities like funerals. During my visit, they said they had almost a million CFA ($2000) in the three padlocked boxes.

I asked the Gouraou-Bozo women about excluding the men from the scheme. They laughed. This was women's business. "Any way, if the men were involved they would use the money to marry another lady," they chuckled. "Of course if they do marry again, we will have the cash to look after their children."

In those boxes was the village's social security. This was becoming a substantial community piggy bank benefitting the social resilience of the community as much as the environmental projects benefitted its ecological resilience.

Chapter 4: Restoring wetlands to increase resilience in Senegal

The River Senegal is West Africa's second largest river, exceeded only by the River Niger. If flows out of Guinea, through western Mali and along the border between Senegal and Mauritania to the Atlantic Ocean. Its flow is now controlled by the Manantali hydroelectric dam in Mali, which supplies power to both the Malian capital of Bamako and the Senegalese capital of Dakar. At its mouth, the Diama dam prevents the incursion of salt water into the large delta region.

With water from both upstream and the ocean managed by dams, the extensive coastal delta of the River Senegal is largely under human control. And natural ecosystems such as mangroves swamps at the river mouth and wetlands across the delta have suffered from man-made hydrological regimes.

They have suffered from flood protection systems that work for urban areas but increase the threat to others, and land and water grabs for large-scale irrigated agriculture that deprive them of the wetlands, fisheries and pastures on which their livelihoods depend.

As a result, fishers, farmers and herders who have traditionally geared their lives to the natural rhythms of the river and its delta, face a very different environment, in which they are at the mercy of human engineering and politics as much as nature. They have suffered from flood protection systems that work for urban areas but increase the threat to others, and land and water grabs for large-scale irrigated agriculture that deprive them of the wetlands, fisheries and pastures on which their livelihoods depend.

Wetlands International has for some years been working with these communities, often in collaboration with environment and human rights advocates and humanitarian agencies, to protect wetland ecosystems and improve the livelihoods, resilience and disaster preparedness of the communities that depend on them. This has sometimes involved taking sides in politically charged conflicts over water and land.

GANDIOLE

Ndeye Fatou Sene stood on the sandy shoreline of a coastal lagoon at the mouth of the River Senegal. The waves lapped at her feet. It appeared to be an idyllic scene, but she had a different take. Ndeye pointed out into the lagoon. "That", she said, "is where my house used to be until four years ago. We lived in a fishing village on an island just there. There is nothing left now. The sea has destroyed it."

She seemed happy, almost coquettish, at the chance to show off her world to foreigners. But the story of what happened to her village is shocking. In 2003, the nearby Senegalese town of Saint-Louis, the former capital of French West Africa, faced heavy floods coming down the river. The dams upstream were full. The flood water was ponding up behind an extensive natural barrage of sand dunes that diverted the river south before it could enter the Atlantic Ocean. One night, in some panic as Saint-Louis was inundated, the authorities hurriedly excavated a channel through the dunes to let the swollen river flow out.

It worked. Saint-Louis was saved. But the rush of water began to widen the four-metre emergency channel. Within a few weeks, water taking the short cut to the sea had created a permanent exit 400 metres wide. Today, the breach is more than two kilometres across. The southern half of the sand-dune barrier is now an island, and some day may disappear altogether.

Meanwhile, the widening breach has exposed the once tranquil lagoon behind the dunes to the full force of Atlantic breakers. They are eating away at the lagoon shores. In 2011, Ndeye's village succumbed. "We lost the houses, the school, the cemetery, everything," she said. Other villages in the delta district of Gandiole have also been washed away.

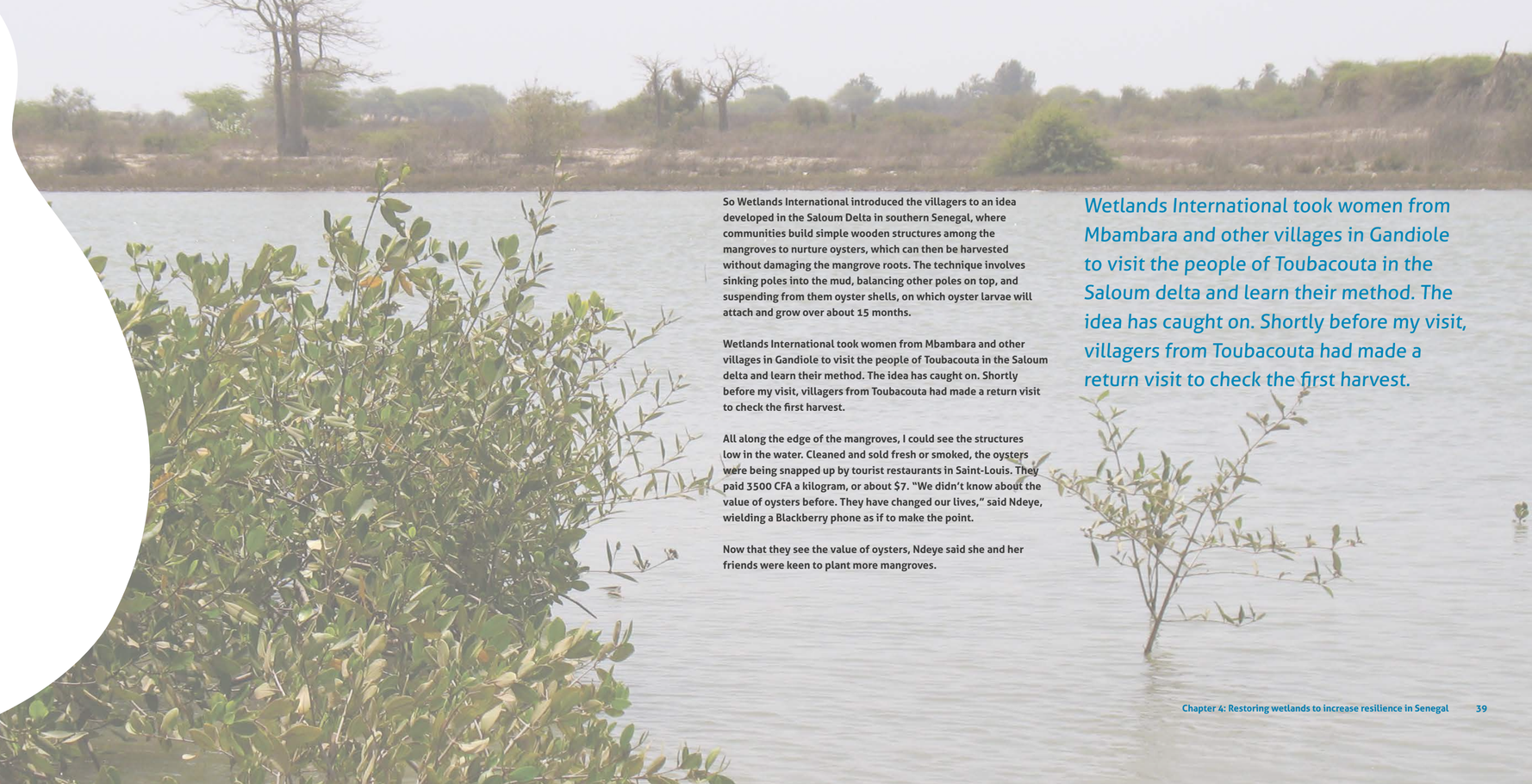
As we stood on the beach, the waves tore away at trees and ripped at the sand. Soon they would break through to another lagoon behind. Surviving villages such as Keur Barka, Mbambara and Diele Mbeme could disappear before many more years are out. The whole of Gandiole seemed at risk – paying the price for a hasty decision to protect Saint-Louis from floods one night a decade ago.

Wetlands International is providing training and seedlings to plant mangroves in what remains of the lagoon. The mangroves will provide breeding grounds for fisheries, attract birds, and absorb some of the eroding force of the ocean.

Wetlands International, which has its West African base in the Senegalese capital Dakar, is offering help to the villages of Gandiole. Their community-based initiative gives some clues as to how ecosystem restoration might contribute to protecting their environment and livelihoods as part of the bigger solutions needed to attenuate the coastal erosion. In particular, it is providing training and seedlings to plant mangroves in what remains of the lagoon. The mangroves will provide breeding grounds for fisheries, attract birds, and absorb some of the eroding force of the ocean.

"We have planted 35 hectares in the past year," said Simone Ndao, the president of the Mbambara women's group, as we embarked on a tour of the lagoons in one of the village's many brightly painted fishing boats. Some planting had worked well. I saw extensive new stands in the lagoon. But near the village, Ndao complained that grazing cattle had eaten other seedlings. "We talked to the herders, but they said it was their custom to graze here and they wouldn't change. We need a fence," she said.

Another initiative has been oyster production among the mangroves. Mangrove oysters have always been caught in small numbers in among mangrove roots, which are a natural breeding ground. The trouble, as Ndeye explained, is that traditional methods of harvesting involved cutting the mangrove roots.



So Wetlands International introduced the villagers to an idea developed in the Saloum Delta in southern Senegal, where communities build simple wooden structures among the mangroves to nurture oysters, which can then be harvested without damaging the mangrove roots. The technique involves sinking poles into the mud, balancing other poles on top, and suspending from them oyster shells, on which oyster larvae will attach and grow over about 15 months.

Wetlands International took women from Mbambara and other villages in Gandiole to visit the people of Toubacouta in the Saloum delta and learn their method. The idea has caught on. Shortly before my visit, villagers from Toubacouta had made a return visit to check the first harvest.

All along the edge of the mangroves, I could see the structures low in the water. Cleaned and sold fresh or smoked, the oysters were being snapped up by tourist restaurants in Saint-Louis. They paid 3500 CFA a kilogram, or about $7. "We didn't know about the value of oysters before. They have changed our lives," said Ndeye, wielding a Blackberry phone as if to make the point.

Now that they see the value of oysters, Ndeye said she and her friends were keen to plant more mangroves.

Wetlands International took women from Mbambara and other villages in Gandiole to visit the people of Toubacouta in the Saloum delta and learn their method. The idea has caught on. Shortly before my visit, villagers from Toubacouta had made a return visit to check the first harvest.

SENHUILE

Voices were raised. Fingers were pointed. And while it all ended in backslapping and smiles, there was genuine anger and some mutual incomprehension. It was the day environmental and human rights NGOs in Senegal came face to face with an Italian company, Senhuile, that they accused of land and water-grabbing in one of the country's most prized wetlands, the 47,000-hectare Ndiael avifauna reserve.

The company denied the charge, claiming that it wanted to revive the desiccated reserve – and with it the imperilled livelihoods of thousands of pastoralists and farmers who depend on it. Where does the truth lie? In the complicated history and hydrology of the Senegal delta, things are rarely simple. But there could be a happy outcome.

The flat lands of the delta south of the river Senegal always used to flood during the wet season, with a series of lakes overflowing into each other. They included the largest lake on the delta, the 50 kilometre long Lake Guiers and the lake at the heart of the Ndiael reserve.

Change began when water engineers harnessed Lake Guiers. For several decades, its supply of water from the river has been maintained by a canal. Both the canal and the lake supply water for large sugar farms, while water from the lake is also piped to the nation's capital, Dakar, 200 kilometres to the south. That has left only diminishing amounts of water for the delta's wetlands.

The regular overflow of Lake Guiers westwards into the Ndiael wetland meant the latter was once a regular home to white pelicans, endemic Adanson's mud turtles, West African manatees and around a hundred species of fish. In 1977, Ndiael was recognised by the Ramsar Convention on Wetlands as a wetland of international importance. But almost before the ink was dry, it lost much of its water.

In the dry years of the 1980s, water managers cut off the main natural channel from Lake Guiers to Ndiael. As a result, the Ndiael wetland became increasingly dry, relying mainly on local rains. The lake at its heart, though marked as a large permanent blue area on many maps, is in reality much smaller and often – as during my visit – entirely dry. In 1990, the signatories to the Ramsar Convention listed the Ndiael reserve's international status as "endangered".

The desiccation of Ndiael was bad for local communities as well as wildlife. Their main asset is their 40,000 cattle, which provide four-fifths of their income, supplemented by irrigated rice and vegetable crops. But they have seen the natural pastures and water channels on which their animals depend drying out. Their vulnerability to drought has grown, and with it their poverty. Ten years ago, some 9000 people in 37 villages in and around the reserve formed the Ndiael Inter-Village Association. The aim was to fight back. It got support from local NGOs, including Wetlands International, which provided expertise and finance to help them revive the channel from Lake Guiers to the reserve.

But then came Senhuile, a company owned by the Italian Tampieri finance group. It persuaded the country's leaders to back a plan for a large farm west of Lake Guiers to grow biofuels for Europe. Most controversially, the 20,000 hectares that the government agreed to lease to the company for irrigation included the northern part of the Ndiael Reserve.

Early in 2014, after a long stand-off during which the company developed its farm, members of the Ndiael Inter-village Association marched in protest at the company plans. The chief of Daymane village, Gorgui Sow, said: "The activities of the Senhuile company deprive us of access to the majority of pastures and sources of food, water and firewood." He called it "a new form of colonisation. The company has made us prisoners in our own land."

Wetlands International and the Senegal branch of the International Union for the Conservation of Nature (IUCN), the world's largest organisation of conservation scientists, backed the association, accusing the company of threatening to take the reserve's last supplies of water for its irrigation.

Mame Latyr Fall of Forum Civil, the local branch of the international human rights NGO Transparency International, told me: "We are here to fight land grabs and help the communities who oppose them. They see strangers coming into their villages, coming to take their land. The company is investing a lot and says it wants to work with the communities. But the communities do not know what it is doing. It says one thing and then a few months later does another." Months after promising it would be growing sunflowers as a biofuel, he said, Senhuile switched to planting rice.

How much water that heads west will actually go to the reserve and its inhabitants, and how much will end up feeding irrigation canals on the Senhuile farm? Some years there may be enough water for all. But, in a dry year, who will get priority? And who will be in charge of the sluices?

Channel taking water from Lake Guiers to the Senhuile plantation, Senegal

Dried up Ndiael lake, Senegal

To the charge of land grabbing, the company says it is providing jobs and assisting communities with infrastructure such as digging wells. To the charge of water grabbing, it says that, rather than taking the reserve's last water, it will actually deliver more water to the reserve.

To secure its water supplies for irrigation, the company has further increased the capacity of the water channel from Lake Guiers. The cleaned-out channel now runs the 18 kilometres all the way to the farm. But it says it is willing to let local authorities take much of the water on a spur to the wetland.

This could happen. The Senhuile project now forms part of a wider government scheme to revive this part of the River Senegal delta, for both nature and agriculture. In 2013, it secured funding from the African Development Bank to spend $24 million on increasing the amount of water taken from the River Senegal to Lake Guiers from 1.2 to 2.1 billion cubic metres by 2017. There are many demands on this water. But the Bank says the aim is to "restore and develop natural ecosystem resources in order to sustainably boost the resilience and productivity of farming systems for the benefit of poor rural communities." And as part of that, more water should flow west towards Ndiael.

This is good news and Wetlands International and their local partners have supported the plan, though it will not resolve the land grab. And questions remain. How much water that heads west will actually go to the reserve and its inhabitants, and how much will end up feeding irrigation canals on the Senhuile farm? Some years there may be enough water for all. But, in a dry year, who will get priority? And who will be in charge of the sluices?

When I visited in May 2014, Senhuile had completed the upgrading of the channel from Lac Guiers to its farm. Water was passing flowing to its fields. Some cattle herders were pleased. One, Adama Ba, who had bought two cows with micro-credit arranged by Wetlands International, brought them to the Senhuile channel for water. "With the channel, everything is going well now" he said. And as we watched local women bathed in the canal and a large unmarked road tanker abstracted water.

> "We are working to improve the water resource for everyone. We want to make sure the reserve also has water at the right time. Not all year, but at the right time."

But there was as yet no sign of the Office du Lac Guiers, a government agency, fulfilling its promise to dig the spur that would take water to the wetland reserve. Nobody seemed sure when, or if, this would happen.

Wetlands International supported the construction of a lookout tower in the wetland so visitors will be able to watch the abundant bird life that should return, once the spur is built and the water starts flowing. But the channel to the reserve remained clogged and the depression where there should be a lake was bone dry. "There were pelicans here briefly in January," Wetlands International's Pape Diomaye Thiare told me. "But right now there is no water because the company is diverting it to its fields."

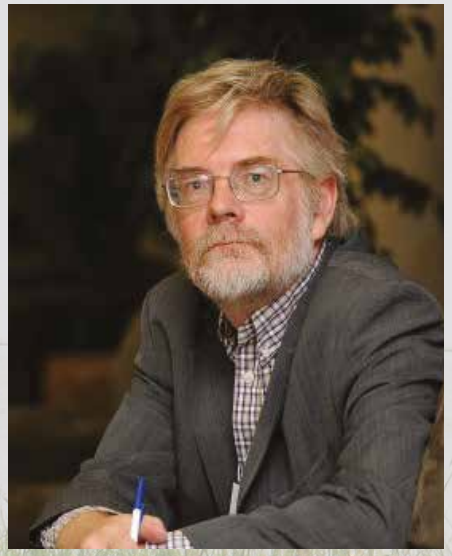
The promises had yet to be fulfilled. It explained the tension at the meeting between NGOs and Senhuile. During a two-hour confrontation in searing heat outside shipping containers that functioned as company field offices, Senhuile's head of security and spokesman on conservation, Colonel Ibrahima Diop, insisted: "We are working to improve the water resource for everyone. We have done a lot for the community. We want to draw water for ourselves without creating problems. We want to make sure the reserve also has water at the right time. Not all year, but at the right time."

The impasse continued until the arrival of the company social director Maura Pazzi, who is in charge of liaisons with communities. Then the mood – and the company line – changed.

"Yes, we have some problems," Pazzi admitted. "We will do our best to fix them. We need to forget the past, and sit down together." The company, it emerged, had been troubled by the outbreak of protests in recent weeks. There would be an effort to mend fences. Perhaps the wetland would get its water after all. E-mail addresses were exchanged, though my subsequent messages to ask about the company's new position went unanswered.

Sitting quietly at the back of the hot-tempered meeting, keeping his cool, had been the man at the government water and forestry department who is in formal charge of the reserve. Moussa Diop [no relation] had kept his counsel as voices were raised. But he told me later: "We are very happy to see a new behaviour from the new team at Senhuile. They are very different from the former team. More open to collaboration."

He agreed that, in his view, "the crisis with communities in recent months is the reason they have changed their behaviour. But if everybody does what they say now, if the company allows water to come to the reserve, and works with the communities, there will be a positive outcome."



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