

# SHIFTING GREEN FRONTIERS



## Green frontiers for development

The San Francisco Bay Area is a unique place. It is unique not only because it is one of the largest estuaries in the US with valuable wildlife and biodiversity, but also because within this same area innovative economic and social developments have occurred and are expected in the coming decades.

This unique place has an equally unique challenge ahead. In the long-term, The Bay Area is threatened by rising sea levels, increased urbanization, and decreased water quality. Areas with a high risk of sea level rise, a high expected urbanization rate and in close proximity to nature preserves pose the biggest challenge.

For these hotspots in the San Francisco Bay Area we propose the adoption of "green frontiers". Green frontiers enable local communities to deal with the challenges ahead, while creating opportunities for development. Green frontiers are self-supporting floating communities with living plots on a strip located off the shore in which existing technologies are applied. These communities are integrated, local solutions that offer placement and replacement of houses, local water treatment, the application of biofilters and renewable energy systems, and a method to create new land.

## Vulnerable deltas: a global problem

The urban global population is expected to grow with an additional 4 billion people in the next 30 to 35 years. For the first time in history, the number of people living in cities will be equal to number of people living in rural areas (UNFPA, 2007). More than 200,000 people already move to cities every single day (UNFPA, 2007). This urbanization is expected to take place predominantly in coastal and river plains that are subject to flooding risks as a result of climate change. In 2003, 23% of the world population lived within 100 kilometers of the coast (Small and Nicholls, 2003). In 2030, this percentage is expected to increase up to 50% (Adger et al., 2005). Climate change will result in more extreme flooding in cities around the world (Kron, 2005), more severe droughts, and more frequent brutal heat waves, resulting in increased water usage. In the urban delta regions like the San Francisco Bay, the risk of flooding is aggravated by sea level rise and land subsidence.

## Delta problems in San Francisco Bay

The San Francisco Bay area is a unique estuary characterized by valuable wildlife of international significance. It is the largest estuary on the United States' West Coast, and is of crucial importance to a number of migrating birds such as the tundra swan, the snow goose, western sandpipers, and marbled godwits. In addition, many of the species of mammals and plants found here are unique to Northern America, like the San Francisco gumpant, the salt marsh harvest mouse, and the harbor seal.

*"Shifting green frontiers is a strip of floating houses that accelerates the process of sediment settlement and expansion of wetlands."*

However, severe degradation has taken place in this valuable habitat. Due to the increased urbanization and land reclamation, the size of the wetland areas has declined 80% over the last 200 years. (Cohen, 2000). Water extraction and irrigation projects have substantially altered the amount of fresh water that enters the Delta area, thus creating higher salinities over the years. On top of this, polluted sediments have had a detrimental impact on water quality. Although the discharge of toxic metals and organic pollutants into the water system has reduced over the years, studies show that still significant quantities of waste water end up in the Bay, including 300 tons of trace metals every year (Cohen 2000).

In the next 100 years the San Francisco Bay will be threatened by a sea level rise of 1.4 meters. A substantial area around the bay is at an elevation low enough to flood if no measures are taken. This rise in sea level will also further degrade the quality of the vulnerable marshes and wetlands in the bay due to increased salinity and flooding.

The bay is also valuable economically. San Francisco is the fourth largest container port in North America and the area is home to a number of growing and innovative industries such as Information Technology, Biotechnology and Biomedical Research.

The beauty and quality of the natural environment in the region and the availability of economic opportunities make the Bay Area an attractive area for new residents. The population of the Bay area is expected to increase by about 1.6 million people by 2030 (www.abag.ca.gov).

## Vulnerable hotspots in the bay area

As stated above, both man and nature in the Bay Area are threatened by sea level rise, urbanization and poor water quality. Some areas are particularly vulnerable. These are the locations that are: (1) vulnerable to flood impacts due to sea level rise, (2) have a high expected urbanization rate and (3) located in close proximity to nature preserves. We have labeled these locations as "the environmental hotspots" in the San Francisco Bay Area. There are 8 of these hotspots which are shown in Figure 1. It is specifically for these areas that the solution of shifting green frontiers is proposed.

## Vulnerable hotspots in the bay area

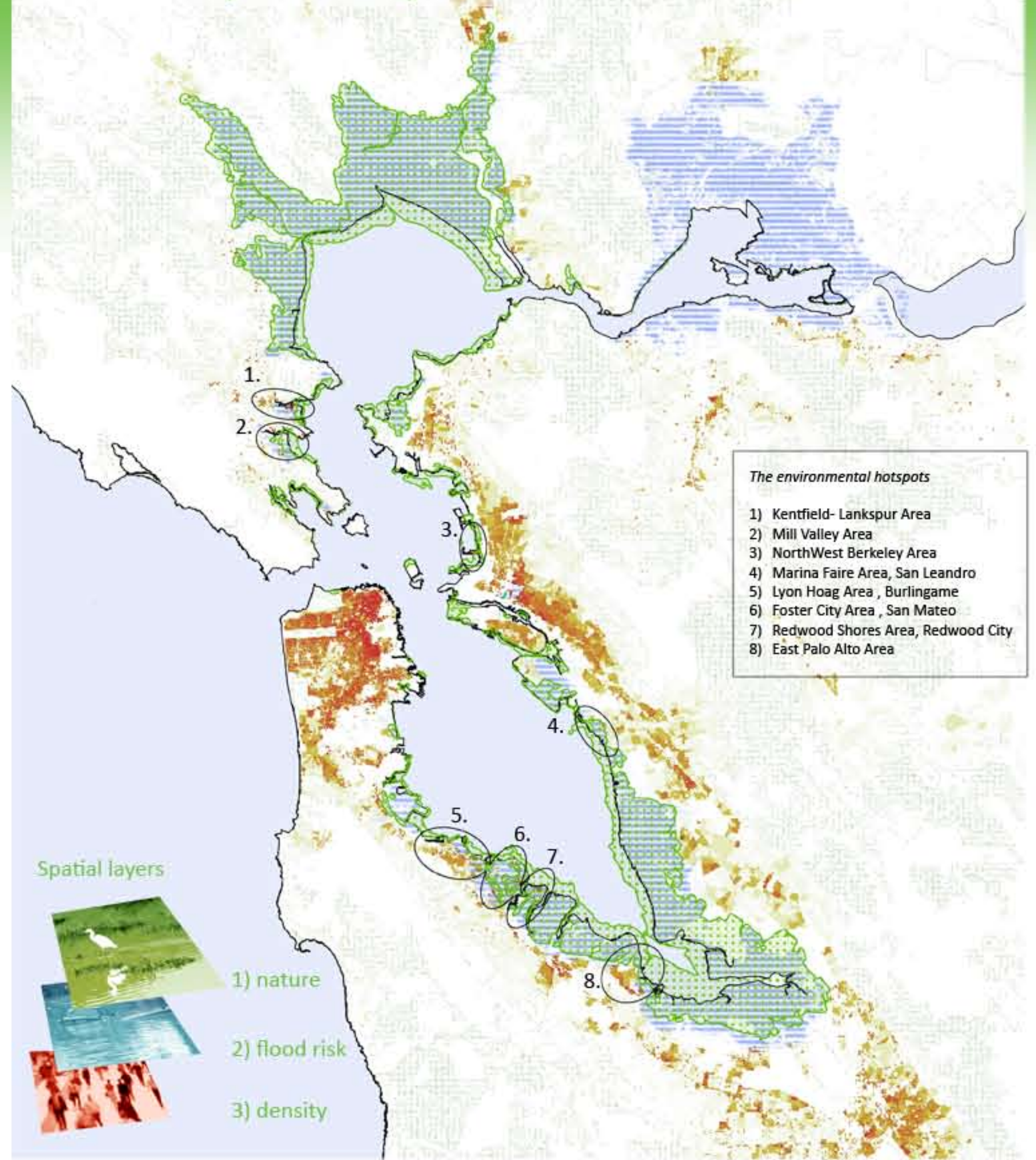


Figure 1: The 'hotspots' are areas which are: (1) located in close proximity to nature preserves, (2) vulnerable to flood impacts due to sea level rise and (3) have a high expected urbanization rate

## Shifting green frontiers: How does it work?

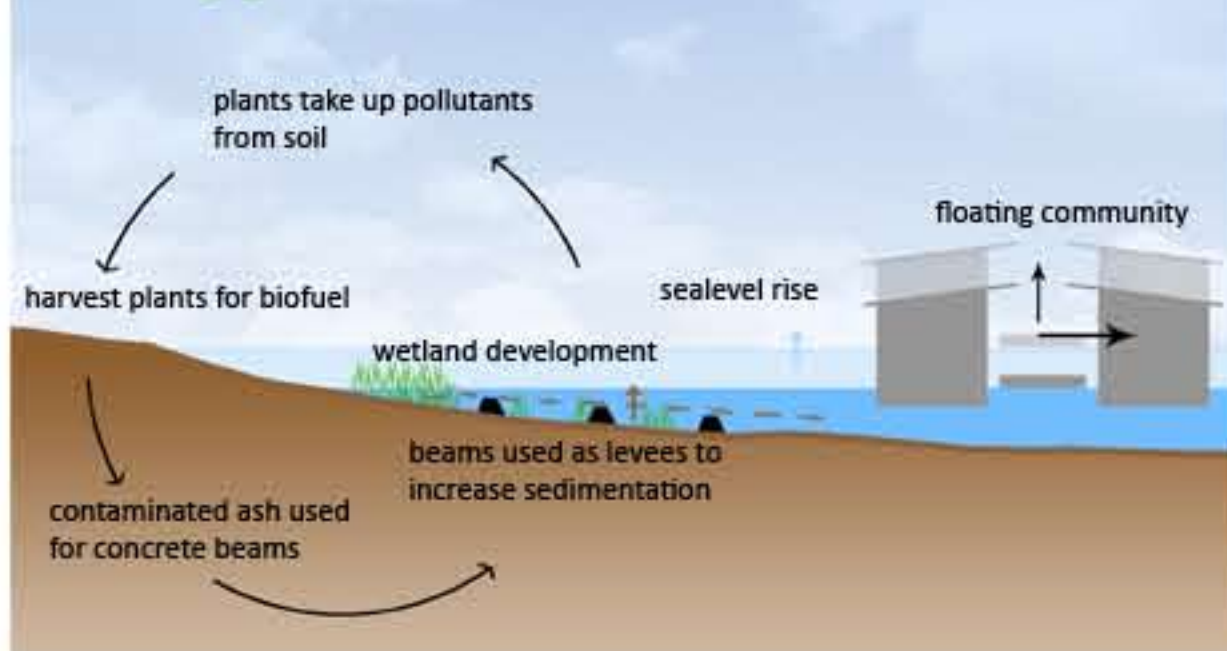


Figure 2: Principle of green frontiers development



Figure 3: The floating community creates a quiet zone where sediments can settle. Recycled concrete beams accelerate this process

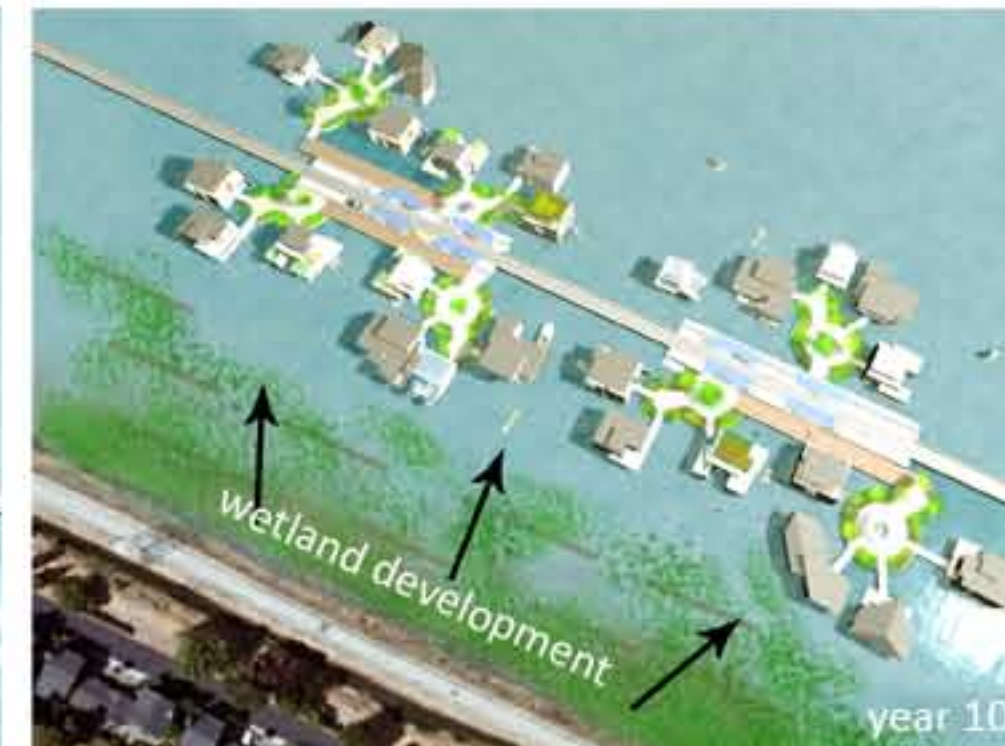


Figure 4: Marshes start to develop as sedimentation is taking place

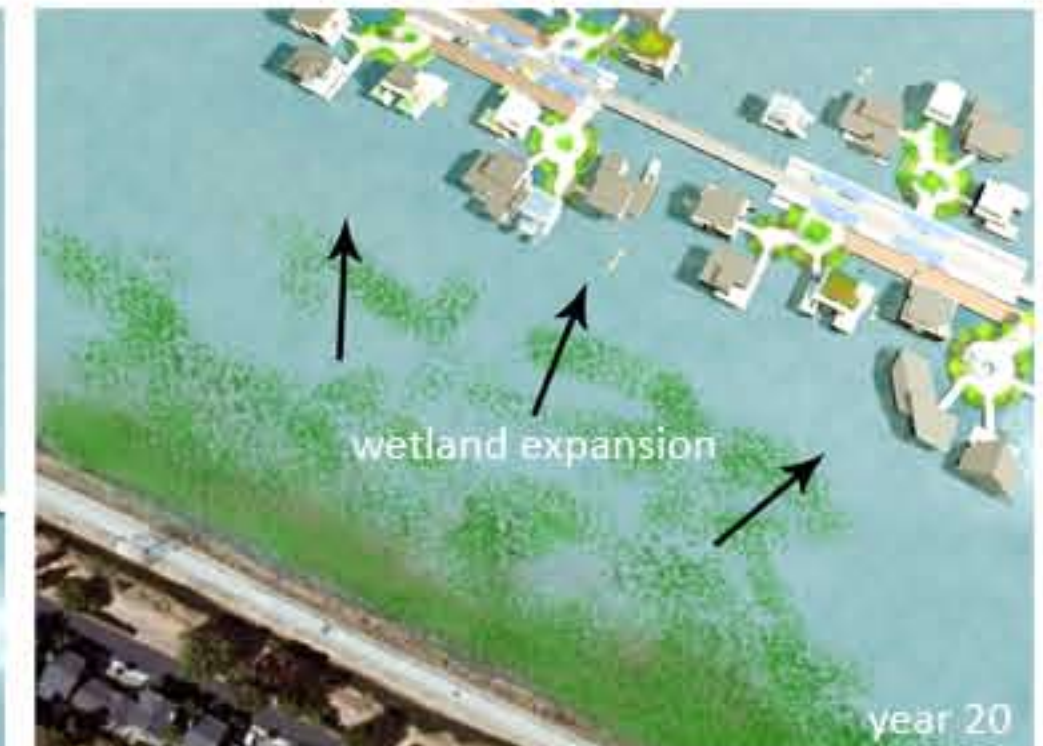


Figure 5: By moving the floating community further from shore, the wetland expansion continues

## How does it work?

By placing the floating community off the shoreline, it creates a quiet zone with limited stream velocity. As a result, sediment can settle and create new wetlands. Application of phyto remediation of the soil will enable the clean-up of pollutants in these sediments (Romkens et al., 2000). Plants will take up heavy metals and other pollutants. When harvested periodically, these plants can be used as bio-fuel to produce part of the community's required energy. The still contaminated ash is used to produce concrete beams. Placement of these beams in shallow waters will accelerate the process of land reclamation and wetland development.

Flexible connections are used to enable optimal placement and replacement of houses. Cables and pipes are integrated into the floating construction that is also used to access the floating district. Permeable pavement purifies runoff before discharging it to the receiving waterways. Biofilters are used to minimize runoff impacts on ecological systems. Rainwater harvesting and local water treatment equipment are installed. Heating and cooling of houses is achieved by installing a heatpump system that extracts heat from the water in the bay. Consequently, no air-conditioning installation is necessary. In addition, solar power is installed. Figure 6 is a rendering of the floating green-frontier community.

The result is a green frontier that creates a wetland that keeps up with sea level rise. This type of development leads to more wetland that plays a crucial function in flood protection. It reduces flood risk of the urban areas around by dissipating wave energy during storms.

After a couple of years when the progress of wetland development is satisfactory, the floating community will move further away from the shore line. The next phase of wetland development starts. In this way, the floating community works as a shifting green frontier.

Green frontiers provide social- and economic benefits. The plots in the floating community will be a very attractive living environment. The ecological and innovative character and the dynamic lifestyle of the floating community relate to the San Francisco Area's progressive and innovative spirit. The floating communities will provide millions of dollars in revenue by selling water plots to the future house owners. The revenue can then be invested in wetland restoration projects in other areas where there urbanization pressure is not as high, such as the San Pablo Bay and Suisun Bay area.

## The result: A more sustainable and resilient San Francisco Bay

Shifting green frontiers is an answer to many urgent problems and long-term challenges in the San Francisco Bay. Shifting green frontiers enable future urbanization without increasing flood risk. Shifting green frontiers create more wetlands in the bay and use the polluted sediments as building material to accelerate wetland development.

Green frontiers combine urbanization with economic development and ecological restoration. Therefore, it is a contribution to a more sustainable and resilient San Francisco Bay.

## The Solution: Self-supporting floating communities



Figure 6: Shifting green frontiers are self-supporting floating communities that enable wetland development and reduce flood risk

## Literature

- Adger W.N., Hughes T.P., Folke C., Carpenter S.R., Rockstrom J. (2005). Social-Ecological Resilience to Coastal Disasters, Science 309, 1036-1039.
- Cohen, A. (2000) An Introduction to the San Francisco Estuary. Save the Bay, San Francisco Estuary Project, San Francisco Estuary Institute
- Kron W. (2005). Flood. In: Munich Re Group. Weather Catastrophes and Climate Change. Is There Still Hope for Us? pp 122-131.
- Romkens P., Bouwman L., Japenga, J., Draaisma C. (2002) Potentials and drawbacks of chelate-enhanced phytoremediation. Environmental Pollution 116, 109-121.
- Small C. and Nicholls R.J. (2003). A global analysis of human settlement in coastal zones. J. Coast Res. 19, 584-599.
- UNFPA (2007). State of World Population 2007, ISBN 978-0-89714-807-8, United Nations Population Fund, New York, USA.