

# Vertical Evacuation: rethinking urban, rural and social space

## Is The Netherlands ready to cope with severe floods?

It is widely acknowledged, that The Netherlands has implemented one of the most excellent engineering systems to contain water and gain land. This has resulted in a peculiar reality in which inhabitants feel safe, but at the same time 55% of the territory is prone to flooding. Against this background the Netherlands now knows very vulnerable areas like the area alongside the coast that is protected by the current flood defence system made up of dunes, dikes and storm surge barriers in which over 9 million people work and live and 65% of the Dutch Gross National Product (GNP) is produced.

Increasing engineered safety systems in addition to industrialization, heavy urbanization, and a fast-growing population have changed the face of Dutch vulnerability and today the risk of flooding is considered rather unlikely, but at the same time potentially catastrophic (see the risk assessments in the national security programme, 2008 (BZK, 2008) and 2009 (BZK, 2009).

Even though preventive measures can reduce the probability of flooding, these cannot completely eliminate the risk of flooding. As the USA experience of Katrina clarified to the world, systems fail. To be able to discuss different measures to reduce the flood risk, the Multiple Layer Safety approach has been introduced. The idea is that different measures aimed at either reducing the

probability of flooding and/ or possible impact can be taken into account with regard to the acceptable level of risk.

With regard to ensuring people's safety in times of large scale flooding, preventive (horizontal) evacuation is still the preferred strategy, in spite of its ascertained lack of feasibility for certain areas. Particularly in some coastal areas where less than 20% of the population is expected to be able to evacuate preventive (in an average situation) before the onset of a flood (Maaskant et al., 2009), it is unfeasible and subsequently undesirable to horizontally evacuate all people. Furthermore, decision-makers will be reluctant to actually call for preventive evacuation in such areas due to such a strategy's impact on economic and social processes. Moving people means stopping social and economic routine, which in turn will result in economic losses, as people are not working (Vrijling, 2009).

An alternative for preventive evacuation is vertical evacuation. Although the risk for loss of life might increase in case of vertical evacuation compared to those who succeed in a horizontal evacuation because people remain in the exposed areas, these people will be less vulnerable than those who are exposed in for instance a car, during horizontal evacuation. There are many pros when it comes to this strategy. For example, less time is needed for vertical evacuation thus the decision to call for vertical evacuation can be postponed which will result in less unnecessary evacuations. In addition, the impact on economic and social processes will therefore be less in case of a preventive vertical evacuation.

The Dutch government acknowledges this and therefore does invite increasing flood preparedness efforts. (Ministry of the Interior and Kingdom Relations, 2005, 2006, Remkes, 2006). Thinking of flood as a "highly unlikely" event constitutes an ulterior threat to the Dutch people as the flood risk perception is rather low in the Netherlands (Terpstra, 2009). However it is known that disaster subcultures and broadly speaking, limited risk awareness can affect a community's response. A better understanding of the problem will led to better decisions during a crisis (Helsloot and Ruitenber, 2004, Tversky and Kahneman, 1974) or measures to reduce the risk.

In light of the above mentioned issues, vertical evacuation has often been discussed as a strategy of last resort in addition to horizontal evacuation in policy documents (Ministry of the Interior and Kingdom Relations, 2008), and related research documents (Kolen et al., 2008, Holterman et al., 2009, Kolen et

al., 2009, Jonkman, 2007) and in innovation programs (Kolen, 2009). Despite this, its implementation and its feasibility have not been discussed. Here, we discuss the feasibility of vertical evacuation. These insights can be used in further discussions about the use of vertical evacuation and to analyze its consequences (loss of life, economic and social damage). We will first present a definition of vertical evacuation as a form of individual protective behaviour and as strategy when planned ahead. Then, we will discuss its feasibility by analyzing political, legal and social implications. In fact, vertical evacuation as a strategic action needs to rethink urban, rural and social space.

## Defining vertical evacuation

Through meetings with practitioners, academicians and Dutch citizens it becomes apparent that there is no common agreement on what an evacuation really is. Evacuation is commonly regarded as temporary relocation of people beyond the threat area in order to reduce the risk for loss of life, rather than as a protective behaviour to reduce the risk. This definition might come from the fact that evacuation is considered a governmental concern, while protective behaviour is typically thought of as an action undertaken at individual level. For instance, in meeting residents from the communities of Borgharen and IJteren we noticed that they termed “evacuee” only those people that had been evacuated by the government (Velotti et al., 2012 a), even though this definition does not mirror the conventional definition of an evacuee, i.e. a person who moves to a (relatively) safe place. This is interesting, because at the end of the day evacuation is not exclusively a governmental issue but rather a form of protective behaviour. In fact, if we focus on the term evacuation as a form of protective behaviour aimed at the achievement of group or individual safety, the range of protective behaviours and therefore ways to evacuate increase.

In figure 8, we attempt to illustrate that evacuation, as a protective measure, can be achieved in different ways and applied at governmental and individual level. The lack of formal recognition of vertical evacuation as an evacuation measure is fuelled by semantics. Evacuation is commonly thought of as the relocation of people beyond the risk area rather than as a protective form of behaviour. Shifting the attention from location towards safest place as the goal of evacuation, allows for different protective behaviours to be highlighted, figure 8 is an example of this. Columns in the figure describe different kinds of movement on the vertical plane (upward movement, no movement and downward movement). Rows show the movement on the horizontal plane as

no movement and movement within and beyond the threat area. The different coloured circles: red, green and yellow refer to different levels of safety. Considering the intersection between upward movement and movement within the risk footprint area, the red circle indicates an unsafe location. The purpose is for evacuees to reach the destination, which is the origin-destination of evacuees. In doing so individuals or groups of people will reach a safer location, (yellow circle), covering a short distance. Finally the desired location will be reached rising up, the green circle.

Figure 8 highlights two main things. First, the same protective behaviour can be achieved in different ways and second, protective behaviour strategies are applied both at governmental and individual level.

In fact, vertical evacuation can be planned in advance from the government or be a spontaneous result of people reacting to a threat. What really characterizes evacuation in general is the different implementation of protective behaviours aimed at reducing the loss of life. These behaviours can be the result of a preplanned strategy or of a more emergent strategy. The distinguishing essence of each strategic protective behaviour is movement

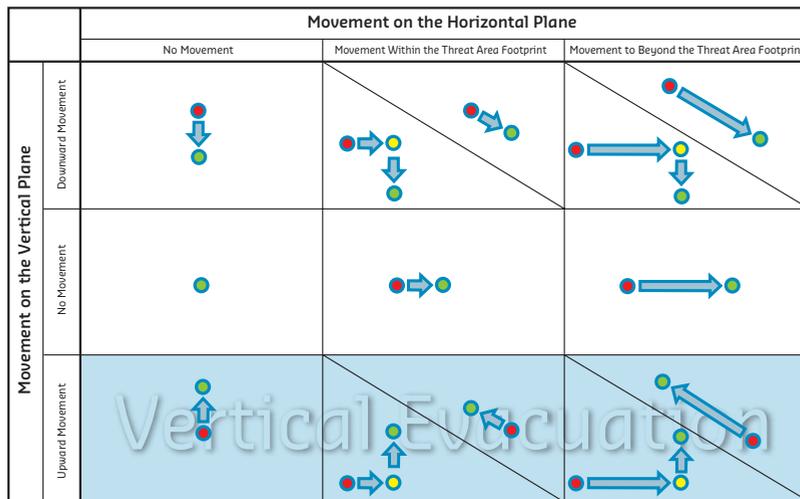


Figure 8 Evacuation as a form of protective behaviour  
 Source: Velotti et al. (2012b). Vertical evacuation as an emergency manager strategy. (forthcoming)

relative to the threat location along the horizontal and vertical planes. “Movement” is not motion, but rather “absolute movement” with respect to the individual initial location. Defining vertical evacuation only as relocation of people within the threat area having them go up loses other options of vertical evacuation, like the individual behaviour to climb a tree, move to an upper floor or a roof and so on. This distinction is due to the fact that in talking of vertical evacuation we always refer to it as a preplanned strategy and therefore as an action organized by somebody for somebody else. In the specific case, vertical evacuation is seen as a governmental attempt to make people safe.

For instance, part of a preplanned form of vertical evacuation can be the development of educational initiatives aimed at informing the population on how to evacuate vertically, which kind of buildings can or cannot be considered safe and why, what do they need to do to be prepared in case of a vertical evacuation, and so on. All these various actions and several others, need to be considered in advance and therefore preplanned. This is particularly true, for those cases in which the implementation of a vertical evacuation has to be done using ex novo buildings. In fact, it might be the case that none of the existing buildings can be used.

An example of the spontaneous reaction of people to a threat is the case of 1999 floods in Veracruz, Mexico. During this event, because of Veracruz morphology, citizens found in vertical evacuation the only resources able to save their lives. In fact, evacuation from their neighbourhoods was impossible. Therefore, people in the flood probe area took shelter in their neighbour’s homes (those who had second floors) and nearby public buildings (Aguirre, 2004).

Thus, vertical evacuation, in general terms, should be considered as a form of protective behaviour aimed at reducing the probability of loss of life. In this light, key elements are the upward movement, within or beyond the danger area, with regard to the location of the subject to be evacuated. If we consider vertical evacuation in this way, we can understand that vertical evacuation is already implemented in The Netherlands as a form of emergent strategy and embedded in some flood subcultures.

## Planning for vertical evacuation

In the USA, vertical evacuation has been studied in response to two kinds of hazards, hurricanes and tsunami. It has been implemented as an emergent strategy during Hurricane Katrina. In relation to hurricanes, the use of vertical shelters began to be considered after it was noticed that high rise buildings can better withstand high wind speed, compared to lower buildings. Thus, for coastal areas more affected by hurricanes, vertical evacuation was considered as an alternative to horizontal evacuation (Stubb& Sikorsky, 1987).

Another use of vertical evacuation in USA is related to tsunami threat. In 2008 and 2009, the American Federal Emergency Management Agency (FEMA) set out guidelines in order to address problems related to the building of vertical evacuation shelters, from an engineering perspective and to guide public officials in the process of implementing a vertical evacuation strategy. When considering vertical evacuation for tsunami, the main focus in USA is related to the realization of engineering structures and tsunami evacuation building (TSEB) with not much focus on the interaction between human behaviour and use of structures. Planning for vertical evacuation together with the interested communities is a new approach. The project "Safe Haven" is one of these attempts. Here, planning for vertical evacuation is understood as a common effort among public officials, scientists and community through a participatory approach.

Vertical evacuation as a strategy to cope with severe flood, was implemented as an emergent protective behaviour during Hurricane Katrina, when citizens were unable or unwilling to evacuate horizontally. For instance, they booked hotel rooms in high-rise buildings. On the other hand, the governmental version of vertical evacuation was the use of the Superdome as a shelter of last resort. It is evident from this that the huge flood in New Orleans was not foreseen and therefore, vertical evacuation was not implemented with a flood in mind. Since Katrina however, and based on their own and the Superdome experience, hotel owners have started to question the desirability of vertical evacuation due to the additional difficulties in the provision of essential services such as water, electricity, food and health care (Troeh, 2006). This highlights very important issues regarding vertical evacuation as a preplanned strategy, namely issues such as liability, partnerships, stock of food, the possible lack of essential services (water and electricity). For instance, from a structural perspective how much risk are we willing to accept in placing people in such a structure?

Another question would be related to the estimated length of people's stay in shelters or places of refuge. Once established how long citizens are expected to spend there, along with the number of people in need of vertical evacuation, the capacity of vertical evacuation structures, the space needed by occupants within the structure and community topography, it is possible to determine the required number of buildings and the features of each building. For instance, a temporary shelter will need different services and amounts of provisions, than a refuge.

The US does have experience and expertise with regard to vertical evacuation in case of Hurricanes, mainly implemented at citizens and private sector level, and they are now attempting to achieve greater expertise on vertical evacuation in case of a tsunami. However the implementation of vertical evacuation in case of severe flooding, has not been studied yet. The only experience was that of Hurricane Katrina, for which vertical evacuation was not a true preplanned strategy aimed at flooding. Thus, while some very important lessons can be learned from the experience of Katrina, there is a great need for further research, in both the USA and The Netherlands. For instance, in case of river floods or collapsing dams, how deep will the water be? Can we forecast its speed and disruptive power? Can a wave generated by a flood be assumed to be the same as a wave generated by a tsunami? In a nutshell, is vertical evacuation a one-fits-all strategy?

While The Netherlands might not have much experience of vertical evacuation as a planned evacuation strategy, it does have a history with it. Looking back through history, you will find that until the end of the middle ages, the inhabitants of both Groningen and Friesland (in the north of The Netherlands), would construct artificial mounds for habitation to ensure 'dry feet' in case of high-water. In fact, it is a rather intuitive response to flooding. For some areas it might in fact be the only feasible strategy. One of the most vulnerable areas in The Netherlands is the dike ring 14 area <sup>4</sup>. Even though a horizontal evacuation plan has been drawn up by various local government agencies, everyone that has worked on this document knows that horizontal evacuation is an undesirable strategy for this region. This area is characterized by traffic congestion on a daily basis. If we imagine the traffic situation in case of a

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<sup>4</sup> In The Netherlands flood prone areas are divided into dike ring areas. These areas are protected against floods by a series of water defences. (Jonkman 2008, 1358). Dike-ring area 14 is the largest dike-ring of The Netherlands and includes major cities like Rotterdam, The Hague and Amsterdam. Approx. 1.3 million people work and live in this area.

large scale flood, everyone would agree that the only real ‘solution’ is vertical evacuation or moving people to a location within the threatened area, that is higher than the perceived threat. However, such a strategy still needs to be reviewed. Despite the logical nature of vertical evacuation as a strategy, it also raises some concerns that need to be tackled if we are to present it as a desirable strategy. First, in order for individuals to be safe they still have to travel horizontally to reach the vertical shelter. Secondly, while required time for getting people to safety is decreased, once the event strikes the area, people will be in vertical shelter surrounded by water which could render the provision of mass care difficult (and people also need to be rescued). Thirdly, the building must be structurally “safe” to withstand the disaster. Otherwise an even greater disaster may be created.



Then the question arises as to how vertical evacuation should be implemented? Preparing plans to shelter people in case of a disaster, in both The Netherlands and the U.S., is the responsibility of the local government. For both countries it must be considered whether vertical evacuation should be seen as a supplement to other strategies like horizontal evacuation, or as an alternative to or replacement for other strategies aimed at reducing the loss of lives? Thus, vertical evacuation as a complementary approach to horizontal evacuation would involve dividing the risk area into zones, some of which would be evacuated to vertical shelters and some of which would use existing transportation networks to evacuate horizontally. In a supplemental approach for example the bulk of the population could be moved horizontally, but with vertical evacuation preparations for those with special needs. Determining which of these is more appropriate, is not a simple task and should be based on careful consideration of the consequences and expected behaviour. Again, the benefits and drawbacks of both approaches should be considered. Investigating, and if desirable, designing and implementing vertical evacuation as a response strategy, will require understanding the various responsibilities, tasks and interests, especially when multiple administrative regions are involved.

## Rethinking urban, rural and social space for a pre-planned vertical evacuation

At first glance, vertical evacuation is a logical and sound approach to providing for the public's safety, particularly in instances where pre-event notification of a hazard is short or particular populations are difficult to move. This solution is a fast and, if well implemented, easy strategy to move people out of harm's way. Here the problem is understanding who the people at risk are, if they are willing to go to a shelter, how many of them are self-reliant and how many have special needs?

The term "special need" has been used widely since Katrina in the USA. The problem however is that few people have thoughtfully considered exactly what this actually means and how the government can support and facilitate the evacuation and sheltering of these people. In reality, it is difficult to determine. Are elderly, physically impaired, mentally impaired, incarcerated populations, people without vehicles, singles, tourists, children, pet owners, etc. special needs? It is important to note that each of these groups is vulnerable for different reasons and planning to meet their

needs may be quite different during horizontal and vertical evacuations. When one considers the mass care needed, after the initial event and the various demands that “stranded” evacuees might have, the importance of considering the reality behind the category becomes apparent. For instance, what kind of services are required in a shelter, or how can the use of existing buildings and personnel be optimized for these special needs populations, in order to minimize costs ?

Time and space are fundamental in every evacuation, so the needs of citizens and their trajectories of geographical movement along time and across space, have to be taken into account. An example of the complexity in planning for vertical evacuation is the simultaneous consideration of multiple factors such as travel time to safety, pertinence of the location and number of sites to be provided. Travel time to shelter must be taken into account, to make structures easily accessible. To do this a walkable distance for the evacuees has to consider the difference in speed paces between able-bodied and disabled people. Underestimation of evacuation times is not uncommon and can depend on simple but important factors, such as waiting in line to use a stairway, the capacity of entry doors, etc. It is important that the many factors associated with site selection are all taken into account.

Choosing the characteristics of a building that will serve as a vertical evacuation shelter is not a simple task, considering that all of these options have benefits and drawbacks. Vertical evacuation buildings can be

1. purpose-built
2. retrofitted existing buildings that are more resistant to specific or more natural hazards
3. existing buildings or structures that are not developed as a shelter, but offer protection and some services and do not require additional investments. They can be
  - single purpose (only a shelter)
  - multipurpose (schools, parking garages, etc.) for which the function of a shelter might not previously have been foreseen. They can be public or private.

Developing an understanding of these choices and how The Netherlands wishes to address them, is of vital importance to a successful implementation. Here it is important that flood safety is tackled through an integrated approach, by including not just engineers, architects and spatial planners, but also social scientists, disaster management professionals and community leaders.

The ability to provide early warning to the population, and the knowledge about possible forms of evacuation, is a critical aspect for the success of an evacuation. However, time is often limited. In this case, the existence of alternatives like that of vertical evacuation is fundamental. In fact, the presence on a given area of vertical shelter can reduce the time needed to bring people to safety (Applied Technology Council, 2008). One of the aims of vertical evacuation is to increase the required lead time of an evacuation, by sheltering the more vulnerable people in vertical structures located on the area that will be affected by disaster. Here, the main question is who counts as a vulnerable person?

Moreover, limited time reflects on travel time to shelters or areas outside flood zones. The latter is generally based on three quantitative traits of crowd movement: density, speed and flow. In order to make structures easily accessible, a walkable distance for the evacuees has to consider the difference in speed paces for able-bodied and disabled people. Underestimations of evacuation times can depend on simple but important factors, such as “waiting to make use of the heavily queued stairs” (Jake, 1994). In addition, the availability of transportation is something to be considered. We have to remember that among the main causes of death during flooding are drowning and car accidents, due to the use of vehicle of transportation, usually personal cars (Jonkman and Kelman, 2005; Alexander, 1988).

Then the question remains as to whether preparation for vertical evacuation should be embedded in legislation, such as the issue of who will pay for building or retrofitting vertical evacuation shelters? The law and the financial issues should be taken into account in order to ensure feasibility of the measures.

Finally, vertical evacuation plans and preparations should not lead people to overstate the “safety” of the interested areas. This is particularly true for coastal areas, and causes people to take risks they otherwise would not take. To do so might lead to pressures from developers to continue to populate areas at risk, such as the coastal regions. It is important to ask how this strategy can make the existing population safer, without serving as a justification for putting additional people at risk.

## Conclusions

For various regions in The Netherlands, vertical evacuation is seen as a strategy of last resort or a more realistic strategy than horizontal evacuation when considering, lead time, population density, transport system and socio-economic characteristics of the hypothetically affected population. Before this can be said, it is necessary to look into vertical evacuation as a strategy. Is it feasible and is it desirable? To do this the above questions (and more) should be addressed by the governments and communities in order to understand what this strategy entails and the preference of the relevant stakeholder groups as well as the likelihood of successful implementation. Experience has for instance shown that even though sheltering people, in case of (a potential) disaster, is a legal responsibility for local governments, it is sometimes extremely difficult to implement. Perhaps even more so when, as in The Netherlands, we cannot rely on our experience of large scale vertical evacuations.

Stakeholders' attitudes towards vertical evacuation also need to be investigated, to if the possibility to vertically evacuate can delay the evacuation on the part of the citizens and significantly delay the issuing of warnings on the part of emergency managers. A survey on their attitudes, perceptions and concerns related to evacuation and vertical evacuation plans would serve two functions. First it would provide some input into the behavioural feasibility of this tactic. In other words are people likely to use it? The second data collection should be aimed at understanding the feasibility of vertical evacuation from an engineering, economic and social perspective. For instance, what would be the requirements of a building, in order to withstand a wave generated by flooding? What are the costs generated by vertical evacuation when compared to those sustained for implementing a preventive evacuation? Who will support these costs?

Finally, worldwide experience of vertical evacuation is available, from countries such as Japan, Indonesia and so on. Collecting the experiences of these countries could be very valuable, especially to help us understand issues related to the implementation of vertical evacuation such as breakdown of services in a shelter, public behaviour and dealing with shortages of food and water, first responders, medical aid, electricity etc.

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