Historic drought and salinity intrusion in the Mekong Delta in 2016: Lessons learned and response solutions

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Abstract:

During the dry season of 2015-2016, the Mekong Delta had suffered the worst historic drought and salinity intrusion occurrence on record, causing heavy damages to nine coastal provinces (in total 13 provinces) of the Mekong River Delta. Just after the drought and salinity intrusion occurred, the media offered some different opinions suggesting possible solution which offer effective responses and stable development to coastal regions. The author suggests that in order to have sustainable development for the Mekong Delta in general and for the coastal zones in particular, Vietnam needs to have some basic short-term and long-term solutions, for each region as well as the whole delta, including drought-salinity intrusion and flooding programs, structural and non-structural works, and coverage for both the Mekong Delta and the whole Mekong River Basin.

Keywords: ***historic drought, Mekong Delta, salinity intrusion.***

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Historic salinity intrusion 2015-2016 in the Mekong Delta

Salinity intrusion is a natural phenomenon that occurs annually in the Mekong Delta and is dependent on the following factors: low-flow from upstream of the Mekong River; water storage capacity during the end of the flooding season in the Mekong Delta; coastal water level happenings; and water use situation in the Mekong Delta. Each year, salinity intrusion often occurs at the Mekong Delta from December to May, with coverage at its peak in late April or early May.

According to water level statistics at Tan Chau (Mekong River) from 1926 to the present, the peak flow and total volume of water in the 2015 flood is the lowest in 90 years for the Mekong Delta, which is to occur at 99% frequency, or once every 100 years. The total water for the overall flood season in 2015 was about 220 billion m^3, approximately half of the largest floods on record (400-440 billion m^3) and 60% of recorded medium floods (350-370 billions m^3). The total temporary water flood storage in the whole Mekong Delta flood zone was shortly below 2 billion m^3 in 2015, just behind that, half of the medium floods (4 billion m^3) and 40% of the largest floods (6 billion m^3). Since the 2015 flood was too weak, the flow into the Mekong Delta during the 2015-2016 dry season was also too low. Discharges at Tan Chau (on the Mekong River) and Chau Doc (on the Bassac River) from December 2015 to March 2016 were only 57-85% of the annual average. The main reason was due to the Mekong upstream flood flow into the Great Lake (Cambodia) decreasing by 33% from its average, leading up to the amount of water input for the low flow into the Mekong Delta (beside of the Mekong upstream flow) from November 2015 to the end of March 2016 decreasing to 53%. If counting the amount of water used along the river, the flow sent to the Mekong river mouth during the same time in 2016 was only about 65-70% of the average, from 1,300-1,500 m^3/s. This shows that the salinity intrusion level in 2016 was more serious than was in 1998 [1].

With the flow conditions described above, salinity intrusion during the 2016 dry season had occurred worse up to now. From the beginning of November 2015, saline water began entering the coastal areas and estuaries, about 1.5 months earlier than usual. Until February 2016, the saline boundaries were approximate with its highest boundary as the average year and from this time, the salinity intrusion are up higher. Until the end of March 2016, saline boundaries of 4 g/l reached the peak of the year, exceeding annual average 20-25 km, even some places over 30 km (Vam Co Tay River). In specific: On the Vam Co Tay River, saline water deeply intruded to 135 km (from the river mouth), passed the Tuyen Nhon 25 km; On the Mekong River, 79 km, near to Binh Thanh island, far from 3-5 km downstream of Mekong and Ham Luong River confluence; On the Ham Luong River, 78 km, passed 25 km from the Ben Tre River mouth (near the town of Cho Lach district); On the Co Chien River, 81 km, passed 2-3 km from Mang Thit River mouth; On the Bassac River, 70 km, passed 2 km from An Lac Thon and far 7 km to downstream from Cai Cui Port. In the Ca Mau Peninsula, saline water intruded to Nga Nam town on the Quan Lo-Phung Hiep canal and the middle of Nang Ren-Cai Trau-Phu Loc canal, adjoining with saline water from Cai Lon-Cai Be river, that forms the pincer surrounded the central area of Ca Mau Peninsula.

Until the end of the 2015-2016 drought-salinity intrusion spell (May 2016), drought had affected all 13 provinces of the Mekong Delta, while salinity intrusion affecting nine coastal provinces (Fig. 1). The total damage across all fields can be calculated up to 360 million USD. In that,

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Fig. 1. Much of the area of rice production in the Mekong Delta were withered due to the effects of salinity intrusion.

according to a report of the Ministry of Agriculture and Rural Development and local authorities, the total damages to agriculture and aquaculture is more than 300 million USD. The damaged areas: For rice, 238,276 hectares (130,280 hectares in 2015 and 107,996 hectares in 2016); For fruit trees, 29,277 hectares; For vegetables, 6,575 hectares; For brackish water shrimp, 79,000 hectares. In addition, the total number of households suffering from the lack of clean water is 211,261 (with over 1,000,000 inhabitants), the estimated cost of implementing the temporary solutions for water supply is more than 22.5 million USD. Other damages are approximately 45.0 million USD, primarily due to additional works to dredge canals and repair and reinforce embankments, cattle and poultry died due to lack of drinking water, epidemics caused by a lack of clean water [2].

Lessons learned from drought and salinity intrusion during 2015-2016

When considering all collected data, an analysis of the causes, impacts, and responses from the historic drought-salinity intrusion during 2015-2016 in the Mekong Delta shows the following:

A need to focus on implementation and to improve the effectiveness of long-term hydro-meteorological forecasts: Problems with the hydro-meteorological forecast, particularly for the long-term, is extremely important. Due to many reasons, so far, Vietnam focuses primarily on short-term forecasts (1-3 days) and medium-term forecasts (3-10 days), and has yet to fully consider long-term forecasts (1-6 months), and have especially neglected very long-term forecasts (3-5 years). From this, we can assume that the prevention of natural disasters has been very passive, even considering drought only, and not yet hurricanes, floods, and other natural disasters.

Long-term and very long-term forecasts hardly require highly accurate data, and often only need to identify a general trend. From this, we must remove the warnings and recommendations to and from the ministries and local authorities to consistently arrange seasonal calendars, cultivated area maps, and prevention and response plans for natural disasters. Instead, we need to instill the point of view that "forecasts are requisite, and warnings are sufficient". The fact that the drought-salinity intrusion happenings from 2016 in the Mekong Delta show that if the forecasts and early warning activities had been heeded at the end of the 2015 flood, then surely the damage would be decreased more than what actually happened. For efficient long-term forecasts, Vietnam can propose to China, Laos, and Thailand to operate flushing activities sooner for the hydro-power reservoirs than at the beginning of the dry season in 2016, which will help to significantly reduce drought-salinity intrusion issues in the next months.

Direct activities to prevent and respond to drought-salinity intrusion: When drought-salinity intrusion occurs, authorities from the local government, central government, and local people try to prevent and overcome resulting damage, but so far, damages caused by drought-salinity intrusion have been extremely large, causing no small hardship for the socio-economic development of the whole Mekong Delta, both in general, and particularly for the lives of millions of inhabitants living in the influenced areas. Considering these damages, it must be said that there are many lessons of which the direct activities to prevent and respond to the drought and salinity intrusion of the authority levels can be used to learn. That is, the central authorities have not yet implemented initiative actions for forecasting and early warning of drought-salinity intrusion situations for local authorities, although the rain and flood happenings in 2015 gave noteworthy information to help study the historic drought and salinity intrusion in the dry season of 2016, and although the drought and salinity intrusion situation happened right from the end of the year 2015, locals did not take initiative, nor did they take actions to direct people to arrange and shift the seasonal calendar, cultivated areas, and other activities. When the process of drought and salinity intrusion occurs, coordination and direction between the central and local authorities are also limited, and should not keep up the drought and salinity intrusion happenings to promptly warn local authorities and local people; using an agreement among Vietnam, China and Laos to flush water using hydro-power reservoirs to reach anti-drought and salinity intrusion is necessary, but if Vietnam takes the initiative to propose these contracts sooner, the issues caused by the dry season of 2015-2016 would be significantly reduced.

A need to consider the overall water discharge by hydro-power reservoirs from China and Laos: The Chinese hydro-power reservoirs operate using a mechanism for water storage from melting ice, Spring

floods, mainly occurring between February and April, with a high reached in March, and flooding due to rains from June to September. During Spring-Summer 2016, temperatures trended higher than average, and the snow melted sooner and bigger in the Tibet region than past years. Thus, the floods suffered by China from the middle of March to the middle of April in 2016 are easy to understand, because of the time when the floods occurred. It should be noted that after the upstream hydro-power reservoirs were built by China, besides mostly discharging a negligible flow through turbines, more water may be discharged through spillways in case there is too much snow melt. Due to the non-members of the Mekong River Commission, China carries almost no binding responsibility to flush water downstream. If the Mekong Delta continues facing severely droughts and salinity intrusion as in 2016, and while the amount of snow melt is limited, China also may find it hard to discharge more water downstream.

In addition to China, Laos is an official member of the Mekong River Commission. Therefore, the country should have a higher binding mechanisms to cooperation with Laos, and Thailand, to discharge water from hydro-power reservoirs downstream to help solve drought and salinity intrusion according to the mechanism of the 1995 Agreement for sustainable development of the Mekong River Basin. However, due to the reservoirs in Laos, both Thailand and the Highlands of Vietnam have modest capacity, and should also be hard can help significantly improve the drought and salinity intrusion situation as in 2016.

Learning from the lessons above, Vietnam should not be too eager to expect water discharged from upstream hydro-power reservoirs, which is considered only as a band-aid measure, and that need to have proactive solutions for effective prevention and response to the drought and salinity intrusion phenomena in the future.

Proposed response and adaptation solutions

To sustainably and effectively respond to natural disasters in general, and drought-salinity intrusion in particular, the Mekong Delta needs to closely apply structural and non-structural solutions. With that, and an understanding of each level of disaster, the Mekong Delta also needs the structural and non-structural solutions to be at corresponding levels. The Mekong Delta cannot use low level solutions to be able to effectively deal with higher natural disasters levels.

Structural solutions

Immediate solutions: local authorities and people should actively repair and complete the sluice/culvert system and saline water preventive embankments, proactive water storage soon when drought and salinity intrusion occur. Every year, local people should have water storage measures implemented at the end of the rainy season (starting from November), decanting fresh water when the tides are high (stating from December) to allow more water to reach fields, according to a scale of agricultural households ensuring that the production of the Winter-Spring crop. In order to supply domestic water to urban areas along the coastal regions (such as My Tho, Ben Tre, Tra Vinh, Bac Lieu, Ca Mau, Rach Gia...), the retrieved water points can be temporarily shifted on the river or creek facing risk of salinity intrusion up to places of more stable fresh water. Temporary fresh water pipeline should also be added to towns and residential quarters. Vehicles should also be used to transport fresh water to hamlets, communes and households. More deep groundwater aquifers should be exploited where there is a stable source of water. Drought and salinity intrusion occurrences should be closely monitored, especially those in the fields, at coastal region and at estuaries to promptly alert and subsequently handle complex situations that may occur.

Medium solutions: The sea dike and sluice systems used for salinity intrusion control at self-contained, stable production areas must be perfected. Increase accessibility to fresh water source for coastal regions via intake canals and sluices from stable fresh water sources. Focus must be on completing water resource systems and projects, such as Can Duoc-Can Giuoc (Long An Province), Bao Dinh-Go Cong (Tien Giang Province), North Ben Tre (Ben Tre Province), South Mang Thit (Tra Vinh Province), O Mon-Xa No (Can Tho city, Hau Giang and Kien Giang Provinces), and other places. Perfect the sea dike system and build dike structures according to the "Water Resources Master Planning for the Mekong Delta under the Context of Climate Changes and Sea Level Rise" document, which was approved by the Prime Minister in September, 2012 (1397/QD-TTg). Focus on constructing and completing the central domestic water supply systems for residential areas there. For coastal municipalities, consider shifting the withdrawn point of raw water to upstream, in order to ensure safety from drought and salinity intrusion. Plan a stable water supply for rural areas that face severe drought and salinity intrusion spells.

Long-term solutions: Consider a solution for large scale structures in the Mekong River estuaries (including sluices of Vam Co, Ham Luong, Co Chien, Cung Hau and Cai Lon-Cai Be) and be proactive with the storage, keeping, and distribution of fresh water while maintaining a stable, large volume of water during the dry season in the regional and inter-regional levels. From now until 2020, the government should quickly construct two sluices at Cai Lon and Cai Be. Following that, in order to proactively deal with drought and salinity intrusion that can continue to happen at intensities greater than was seen in 2016, the government should speed up plans to construct remaining four sluices soon after 2020 (approved to plan after 2030). It can be shown that when the large sluices are constructed at estuaries, the fresh water supply and storage capabilities for the entire Mekong Delta will be significantly improved. Fresh water will not only be stored at a mass of billions cubic meters, but will also be supplemented by about 40-50% to the Mekong river (Tieu and Dai mouths) and 10-20% to the Bassac river (Dinh An and Tran De mouths) than naturally occurs, which will help to keep the saline boundaries at a safe distance much more than at present. Also from there, fresh water sources could be more favorable in order to transfer water to any difficult water supply regions, such as Vam Co, Cai Lon-Cai Be, the Ca Mau peninsula, and the coastal areas of Ca Mau and Bac Lieu Provinces. Besides that, there is a need for upstream Mekong countries and the Mekong River Commission to establish operation regulations for upstream reservoir systems. These are the basic solutions for a long-term solution in order to respond most effectively to the instability of a flow from upstream and increased climate changes and sea level rises in the Mekong Delta (Fig. 2) [3].

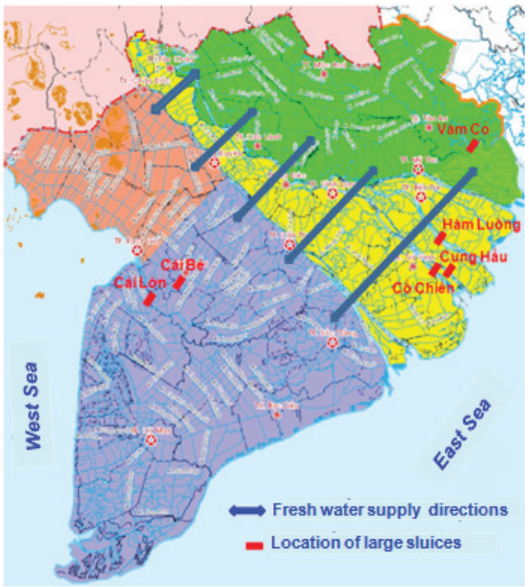

Fig. 2. The locations of six proposed, large sluices and fresh water supply directions from the central Mekong Delta.

General non-structural solutions

The basic point of view of non-structural solutions, is that all structural solutions available to respond to natural disasters cannot prevent all of the extreme values, especially for salinity intrusion at very high levels, exceeding the capabilities of the structural system. For all of the years of drought and salinity intrusion occurrences, should all efforts be responded to by structural solutions, it would not be rational for both economic and national resources. Thus, for inhabitants of the coastal region, they should gradually adapt to the saline environment, living with saline water, and at the same time, emphasizing proper control of industrial and agricultural developments in the coastal regions. In management of drought and salinity intrusion by structural solutions, development management and reasonable exploitation of saline region is extremely important, because this is the most basic foundation for subsequent activities in the natural disaster management by the non-structural solutions. Development management and reasonable exploitation of saline region is demonstrated in the following main activities:

First, the management of socio-economic development in the coastal strip that deals with saline intrusion must not have adverse and negative effects on the environment. This can be done by trying to comply with the natural rules of the world, including the use of embankments, sluices, fresh water transfer canals, pumping stations, and other environmentally-friendly methods; transportation works including roads, waterways, and ports; natural disaster prevention works including dikes; and coastal works since this is the most powerful impact to the saline process.

Second, there must be a reasonable and wise use of saline water sources and products from estuaries and coastal areas for aquaculture and special progress of estuarine biodiversity. Management of the catch and use of natural aquatic resources must also be there.

Third, allowable limits must be enforced on crops, livestock and plant frames (especially rice crops and varieties) as progressing towards drought and salinity intrusion resistant crops. For example, in areas where locals producing two fairly stable rice crops, if severe salinity intrusion occurs and there is not enough water, the locals can switch to plant vegetables. In areas where locals produce two precarious rice crops which are often threatened by salinity intrusion, locals can switch to planting one rice crop and one vegetable crop, or one rice crop and one shrimp crop. In the case of unfavorable conditions, it may transfer to only aquaculture. The coastal regions should closely monitor annual occurrences of salinity intrusion to reduce the area used for early Winter-Spring rice crop in order to avoid concentrated water requirements on January and February, making the saline boundary higher. Also, reducing the later Winter-Spring and early Summer-Autumn rice crops to limits using too much fresh water during the lowest flow duration of year, particularly from the end of March to beginning of May, and switching to vegetable crops. However, to avoid causing large disorder and affecting other rice production areas, locals need to carefully plan and consider the implementation of transference on a large scale, do not make individual households to do not affect around and the whole region.

Fourth, organizing the relief, restoration and execution of drought and salinity intrusion damage insurance which will help carriers to share losses, and enhance the community's education about natural disasters. Risk awareness programs, including community education, information dissemination, and awareness in order to reach the highest level for the community capable of self can immediately response with natural disasters without much support and intervention from outside.

Fifth, propagandizing and informing the community about important activities regarding awareness of the risks of damages caused by drought and salinity intrusion. The strategies used for media activities should change to suit each specific audience. Setting up an information system, through which, the relevant and accurate information about the natural disaster prevention and mitigation for drought and salinity intrusion should be frequently propagated through the appropriate media channels.

Sixth, management activities of non-structural solutions must include contingency plans that consider loss and damages caused by drought and salinity intrusion.

Conclusions

The Mekong Delta plays an important role in the National Food Security Program on an international scale, especially to the population and economy of the coastal region of the Mekong Delta. Therefore, when faced with natural disasters gradually trending towards extremely values, "masterful flow security" is available as an important national strategy, and policy for the present and the future of Vietnam in general, and the Mekong Delta in particular. Continued study into solutions for storage, keeping and provides stable low flow, initiative control of salinity intrusion, and responding effectively with the impacts from climate changes, sea level rise, and upstream activities, are extremely important in the development process of the Mekong Delta.

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