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NATURAL DISASTER MITIGATION IN CENTRAL VIET NAM: INTEGRATION TIMES TWO

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ABSTRACT: The Quang Ngai Natural Disaster Mitigation Project (QNNDMP) in Central Viet Nam has the objective to reduce vulnerability and improve the long-term prospects for communities that have historically been severely affected by typhoons and flooding. From 1996 to 2000, natural disasters of floods and storms resulted in 325 deaths, the loss of 90 fishing vessels and a total damage cost of AUD$140 million. The project features a unique integration of floodplain and coastal issues in terms of addressing Natural Disaster Management (NDM). Further, integration occurs across the elements of the project design: structural works, non-structural risk management planning; and community-based activities. The paper discusses numerous issues where this integrated approach provides value. The paper suggests that a worthwhile form of NDM activity in developing countries, with a particular focus on poverty alleviation, has the following ingredients: integration of coastal and floodplain considerations; integration of structural, non-structural and community-based elements in the project design; development of medium and long-term planning as an essential tool to mitigate future disasters; (where appropriate) advanced two-dimensional modelling as a focus for the planning effort and as a catalyst for political and community understanding and agreement; capacity development for the management and mitigation of typhoon and flood impacts.

1. IMPACTS OF NATURAL DISASTERS IN CENTRAL VIET NAM

The combined pressures of high poverty levels and the annual threat of disaster through flood or storm (typhoon) during the storm season in Central Viet Nam have a severe impact on the prosperity and long term prospects of the region. Viet Nam has very high levels of poverty on a world standard with poverty levels greater than 20% common in Central Viet Nam. The Central Region also has a topographical and climatic environment that is vulnerable to rapidly rising floods and intense typhoons.

The Region is also experiencing industrial and commercial development on a scale not seen before. Thus, with inappropriate filling of low-lying land and local development that can have wide-reaching impacts on other coastal and floodplain communities, the likelihood of worsening disasters is high. Indications of this were seen in 1999 when a typhoon and floods in the Central Region caused over 700 deaths and over $500 million damage.

Poor families in rural areas are particularly vulnerable to the impacts of natural disaster because they have little capacity to absorb impacts such as the loss or damage to their dwellings, the loss of livestock or destruction of their crops. Similarly poor families in coastal communities are vulnerable in that the loss of the fishing vessel is a loss of their dominant investment and is sometimes accompanied with the loss of the major bread-winner.

It is because of the large impact on the poor that assistance through natural disaster mitigation is a key focus area for aid funding from many international donors. In particular, Central Viet Nam has been a focus for the Australian government's agency for international development, AusAID, through the A$15 million Quang Ngai Natural Disaster Mitigation Project (QNNDMP).

The project features a unique integration of floodplain and coastal issues in terms of addressing Natural Disaster Management (NDM). This integration occurs across the structural elements (floodplain works and a safe harbour); and across non-structural elements (modelling for planning purposes and community-based risk

management in floodplain and coastal communities). The community-based focus is different in these two different communities.

Further, integration occurs across the elements of the project design: structural works, non-structural risk management planning; and community-based activities.

For this reason, it is contended that mitigation of the disastrous effects in this region benefits from the approach adopted in QNNDMP – integration across two fronts – the physical and the approach to design: "Integration Times Two".

2. PROJECT SETTING

QNNDMP is jointly funded by AusAID (80%) and the Government of Viet Nam (20%). The overall objective of the project is to reduce vulnerability and improve the long-term prospects for a community that in the past has been severely affected by typhoons and floods. KBR (Kellogg Brown & Root Pty Ltd) led the design efforts for the project and commenced implementation in February 2003 with the establishment of a team and office in Quang Ngai city. The project was planned to be completed in November 2005 but requests by the provincial government for new disaster mitigation activities will result in completion in 2006 or early 2007.

Quang Ngai Province (Figure 1) is located on the coast in Central Viet Nam approximately 140 kms south of Da Nang. The Province has a total population of 1.2 million, of which 80% live and work in small farming and fishing communities along the relatively flat coastal plain. In all, a population of over 600,000 (or 50% of the total province) is affected by floods and storms (typhoons), and in some particularly vulnerable areas, flood depths are over 3 m for 5 year and 10 year ARI events.

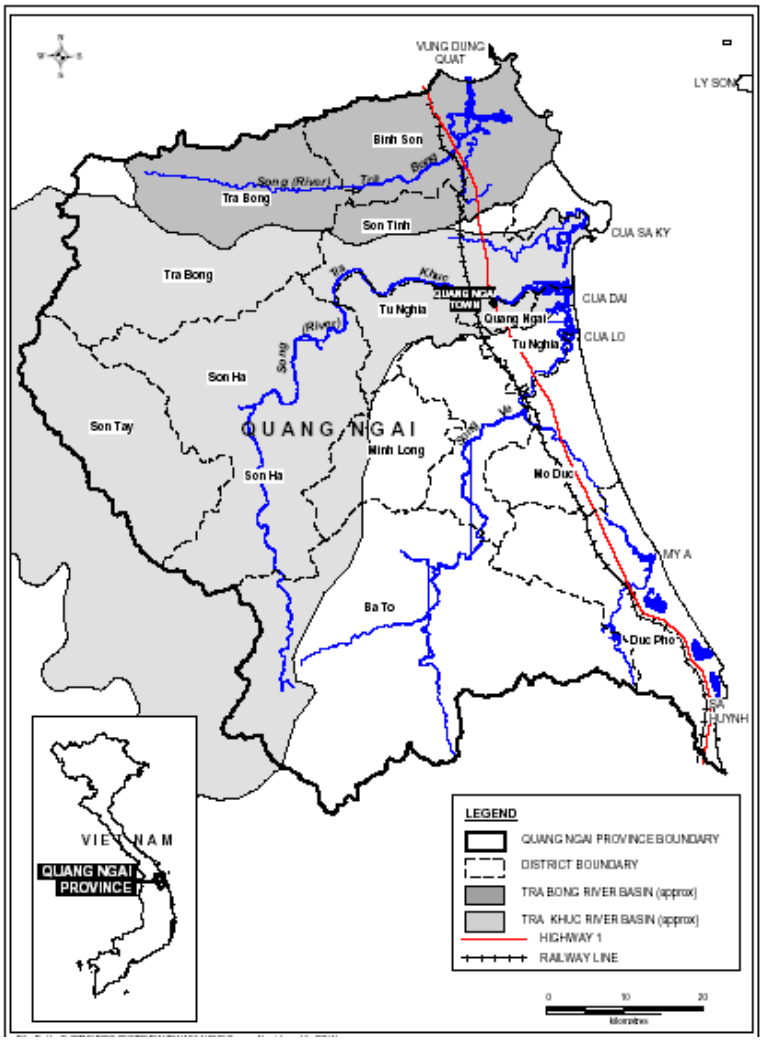

Figure 1 – Location Map

In the five year period from 1996 to 2000, natural disasters of floods and storms resulted in 325 deaths, the flooding of 207,000 houses, including the loss of 5,500 houses, the loss of 90 substantial fishing vessels and the destruction or damage to 1,400 classrooms. Total damage costs for this period exceeded A$140 million. Losses to life and property were coincident – the "event" is usually one of flood and storm. This demonstrates the close link between floodplain and coastal environments in terms of natural disaster and why risk management needs to look at both aspects in an integrated manner.

The key components of the project are:

- A river basin management plan;
- Community-Based Natural Disaster Risk Management (CBNDRM);
- "Demonstration" infrastructure works including riverbank protection, surge control dykes and a safe harbour.

The river basin management plan in turn incorporates three parts: a floodplain management plan; a riverbank management plan and a fisheries infrastructure management plan. The hydraulic modelling is a key feature of the management plans. The floodplain management plan provides a "blueprint" for the future management of land based activities to limit the potential negative impact from on-going development on existing vulnerable flood prone communities. The riverbank management plan, incorporating sediment management issues, provides a structured approach to potentially costly infrastructure. The fisheries infrastructure plan looks ahead to safer anchorages and navigation as well as testing wider impacts in the area as a whole.

Two dimensional modelling and floodplain and coastal management planning are both relatively new concepts in Viet Nam. This, combined with the difficulties of obtaining reliable and consistent data and the sheer scale and complexity of the floodplain, created some interesting challenges for the project hydraulic modelling team.

3. CHARACTERISTICS OF THE PROJECT AREA

The project area encompasses three major river systems: Song Tra Khuc, Song Ve and Song Tra Bong. The catchment areas are 3,250 km^2, 1260 km^2 and 700 km^2 respectively. The rivers mainly run from West to East crossing the flat coastal plain which typically varies in width from 10 km to 16 km. The upper reaches of the catchments rise in the mountains to approximately 1400 m to 1600 m.

The climate is dominated by a strong monsoon from mid September to December. Of the total annual rainfall of 2400 mm at the coast, 1760 mm or 73% falls during the monsoon. In the highland areas of the upper catchment, the mean annual rainfall is in the order of 3500 mm.

The lower floodplains of the two larger rivers, the Tra Khuc and the Ve combine via a coastal waterway and a complex system of floodplain channels that drain collectively via a combination of three river mouths (refer Figure 2). The total flood affected lowland area of these two rivers is 350 km^2. While the project area for the floodplain management plan only covers the Tra Khuc River, it was necessary to model both river systems.

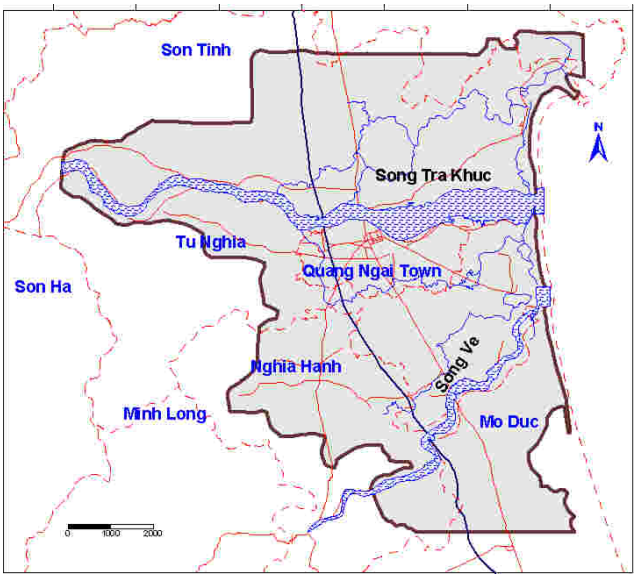

Figure 2 – Song Tra Khuc and Song Ve Model Area

The Tra Bong River lies 20km to the north and is not connected to the other systems. The Tra Bong River in the lower floodplain area bifurcates a number of times into a network of interconnected waterways. The flood-affected low land area is 75 km^2. The objective in undertaking the work in two floodplains was twofold: major works were being proposed in both floodplains and modelling was needed to test outcomes; and the project provided value in demonstrating an NDM approach to both a large and smaller river basin.

Flooding in both floodplain systems is strongly influenced by the embankments from main north-south rail and road routes. The embankments intersect the main direction of flow at right angles and are typically raised up to two metres above the surrounding floodplain to provide some flood immunity. In addition, development (land filling for residential and commercial purposes) tends to ribbon out along these main routes. Culverts and bridges are few and far between for the quantity of floodplain flow hence the combined effect is that there is considerable afflux across the embankments.

Other significant floodplain features include raised embankments for irrigation channels, flood protection levees around population centres and aquaculture ponds built out into the waterways in estuarine areas.

Infrastructure in the region is developing rapidly with several new proposals for major roads, industrial areas and further flood protection levees. Additionally in many estuary areas, unplanned and unlicensed development of aquaculture ponds continues to encroach on the waterways. This ongoing development pressure, together with a perceived worsening of flooding over recent years, is the driving force behind the need for a coordinated and holistic planning approach. A floodplain management plan requires a hydraulic model as the basis for assessment. Further, a two-dimensional hydraulic model was considered the only suitable approach to simulate the complex nature of the floodplain and estuarine systems and the development options under consideration.

4. INTEGRATION 1 – FLOODPLAIN AND COASTAL

This area of Central Viet Nam also has the distinguishing characteristic of dependency on fishing. Every estuary has a fleet of small to medium sized fishing vessels that venture to sea for a variety of fishing products. Despite the fact that seafood has a relatively high value, the communities that rely on fishing for their incomes are generally some of the poorest in the floodplain/coastal areas.

Fishing is generally not regarded as a safety focused activity. The boats and equipment suffer from lack of maintenance expenditure; the many waterway / ocean interfaces are mostly subject to siltation and hence limited navigation depth; safety equipment on board is often very limited or not used; the estuaries have limited safe anchorages for the thousands of vessels that shelter there during typhoons and floods; and the typhoon warning systems are limited and depend on individual boat owners having receivers on board and operable. Fisher people themselves also are not regarded as having a safety conscious attitude, certainly when it comes to risks.

For these reasons, natural disasters in the form of typhoons and associated floods can have dramatic effects on coastal communities. Damage to or loss of fishing vessels is common, and loss of life associated with the boat loss results in loss of income potential for the surviving family.

The interaction therefore between floodplain, estuary and coastal is important when one considers natural disasters in coastal provinces and the impacts on poverty.

Yet commonly, aid effort in the past has rarely combined these considerations in the one package. One reason for this situation is that often the donor at the design stage interacts with one agency. In Viet Nam, most natural disaster related activity is developed at the national level with the Ministry of Agriculture and Rural Development (MARD) and at the provincial level with the Department of Agriculture and Rural Development (DARD). These agencies are mostly concerned with rivers, reservoirs and irrigation as well as estuary bank protection against tidal intrusion into lowland agriculture.

The Ministry of Fisheries (MOF) and Departments of Fisheries (DOF) are concerned with coastal issues as they affect fishing activities and fisher safety. DOF has a Fishery Extension Centre (FEC) that in particular directs its attention to improving safety. Development and implementation of safe harbours for fishing vessels has occurred in a limited fashion to date but currently is receiving more attention in MOF. The Ministry of Transport (MOT) covers the operation of harbours and the development of safer navigation routes through river mouths is an issue for MOT.

With this mixed responsibility, one can see that often development projects focus on one area rather than an integration based on the physical setting. However QNNDMP is different and the success of the project in terms of this integration across floodplain and coastal and across responsible agencies can be a demonstration of cooperation that provides broader benefits than individually isolated activities.

The integration in QNNDMP is demonstrated on a number of fronts:

- Computer modelling that examines rivers, estuaries, river mouths and floodplains. Safe harbour proposals can be checked in the models to ensure no adverse impacts, as can aquaculture proposals for estuaries
- Infrastructure works for NDM were implemented for DARD in the form of riverbank and estuary protection and for DOF in the form of a safe harbour for approximately 350 fishing vessels
- CBNDRM was implemented for vulnerable communities in floodplains where rice production was the norm and for coastal communities where fishing was the common activity. Some communes of each form were located in very close proximity
- An improved attitude to safety was targeted in both types of communities, but the nature of the need is different. An initiative for safety awareness of school children was common to both and 850 teachers and 60,000 children have been taught flood awareness in QNNDMP. While floods have taken lives since the program started, no schoolchildren have lost their lives in the project area
- Fisher safety initiatives have included attitudinal change, the provision of community-based radio transmission facilities that already have saved many vessels and lives and the provision of subsidised life-jacket sales that has seen a very pleasing uptake in ownership and use
- Inclusion of a Fishing Infrastructure Management Plan in the suite of plans under the River Basin Management Plans.

The provision of the safe harbour addresses a very pressing need in the Central Region. In Quang Ngai, there are thousands of fishing vessels in each river estuary. The river mouths are particularly dangerous during typhoons as the vessels try to return to the home base. However the loss of most vessels comes about when the vessels are crowded together in the local estuary and the high-velocity and debris-laden floodwaters take them from their impromptu moorings and carry them back to the river mouths.

In QNNDMP, the design therefore favoured an estuary harbour that would effectively take 350 vessels out of the dangerous river situation. The provision of the facility also enables much improved off-loading facilities that will lead to efficiencies for the industry and an improved environmental outcome. The design of the safe harbour is seen in Figure 3.

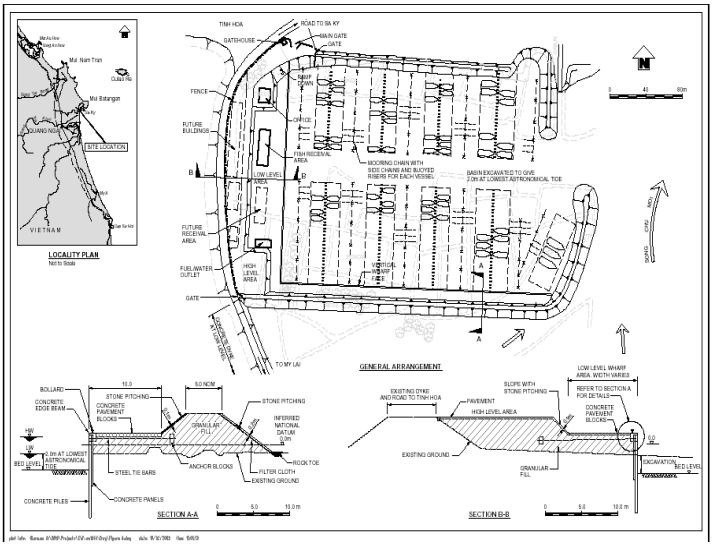

Figure 3 – Concept Design for the "Safe Harbour" in Sa Ky Estuary

5. INTEGRATION 2 – STRUCTURAL, NON-STRUCTURAL AND CBNDRM

After the disastrous typhoons and floods of 1999 in Central Viet Nam, a multi-donor mission in 2000 identified 22 programs that could provide natural disaster mitigation for the region. The programs were evenly split between structural and non-structural programs. The multi-donor mission also led to the establishment of a NDM Partnership of donors and the Government of Viet Nam (GOV) that continues to urge both types of programs.

However it must be remembered that implementation occurs at the provincial level. At this level, department agencies such as DARD and DOF are faced with the urging of communities for physical works to arrest obvious problems such as riverbank erosion and the consequent loss of houses, frequent flood inundation resulting in requests for protective levees, coastal erosion and siltation resulting in requests for dredged channels and sea dykes and frequent vessel loss leading to the desire for safe harbours.

While non-structural measures such as good planning and community self-help in preparation and mobilisation during events will have longer term good, it is difficult for provincial level leaders and agencies to envisage and adopt these measures. Some national agencies are supporters but they have little influence when it comes to actual implementation, especially when some GOV funding is also being provided.

The ideal model therefore seems to be one of integrating structural and non-structural programs, and including in the latter community-based activities. The structural elements provide the incentive for the provincial authorities; the community-based work provides local support and real value at the grass-roots level; and the non-structural element in the form of longer-term planning provides a basis for true alleviation of the problem. By implementing all elements, all parties to the project get to see the benefits of each program and this can lead to a change of attitude.

QNNDMP provides a most successful demonstration of this outcome. While the structural works were sought by the province, they accepted an integrated package. In the latter years of the project, the province has been most supportive of the CBNDRM work and the modelling and planning to the extent that they have, of their own initiative, sought more of the latter two elements without any insistence on associated structural works.

It should be noted too that the provision of structural works also gives the opportunity for new mechanisms in their delivery. In QNNDMP, real success has been noted in the trials of softer riverbank works, the use of vegetative erosion prevention works and the first application in Viet Nam of acid-sulfate prevention works.

The remainder of this paper discusses more of the outcomes related to the planning, and in particular the role of modeling in that process.

6. MODELLING AS A CATALYST FOR POLITICAL AND COMMUNITY INVOLVEMENT AND AGREEMENT ON PLANNING

While natural disaster mitigation has been advocated as a means of alleviating a major problem for Viet Nam, the QNNDMP appears to be the only project to adopt floodplain modelling as a core undertaking in such projects. Why?

Perhaps some of the reasons for reluctance to use floodplain modelling are:

- Limited understanding of the technology itself and of the models' abilities to demonstrate and check the impacts of proposed changes in the floodplains
- A perception that this is a "hi-tech" approach not appropriate to a developing country
- A perception that this is an engineering approach yet risk reduction needs to be community driven
- A view that the solutions lie in physical protection, not desk-top modelling.

What this reluctance fails to recognize is that:

- Current two dimensional floodplain modelling, while still requiring specialist expertise, has advanced to the stage of being a very good demonstration tool to political, administrative and community groups

- In Viet Nam, there are very many areas where the two-dimensional nature of flooding and storm surge is at the core of the disaster problem. Inadequate understanding of the impacts of any development and filling in the floodplain has been, and will be, a prime cause of disasters becoming worse
- In some ways, this advanced technology is more appropriate, and most needed, in floodplain and coastal areas of developing countries
- Not only can such modelling check the appropriateness of proposed structural works, but it can refine design so that the protection is still provided but in a manner that does not increase disaster potential elsewhere
- Current modelling produces graphic on-screen demonstrations of the core issues for management. This leads to common understanding of the issues, and the likely outcomes of planning and development choices. In this way, politicians, administrators and communities become one in their understanding for the best options for disaster mitigation.

This final point has been aptly demonstrated by the QNNDMP. The project has three components and each progressed through the early years. These were:

- Demonstration infrastructure works aimed at physical mitigation
- Community based disaster management empowering communes and community organisations to plan and prepare for potential disasters
- Modelling to understand "nature's" behaviour and test options for planning and ongoing management.

As the project progressed, the modelling also tested the proposed infrastructure works to ensure acceptable designs, and community leaders, on viewing the modelling results, became aware of the nature of flooding beyond their local area and developed an understanding of the holistic nature of flooding and the floodplain management needs. Similarly open meetings and model demonstrations gave all agencies the same understanding and these meetings developed agreed criteria for floodplain management.

Thus, not only was the modelling an important component but it became the catalyst for unifying opinion on the need for floodplain management and the criteria for management and planning decisions. The spectrum of groups vitally affected by disasters – politicians, agency administrators and communities have been drawn together by a common understanding facilitated by the modelling.

This is reinforced by subsequent outcomes such as the request by the PPC for long term capacity to use the models as planning tools and the desire of the PPC for a disaster management centre which maintain the models and continues the interaction with agencies and community groups. Further evidence is the desire of commune groups for detailed model outputs for their areas and involvement with the proposed centre on the design of local schemes for risk management.

On reflection, the modelling is not the critical outcome of the project but it is a critical methodology for bringing project outcomes together and importantly a catalyst for bringing common understanding to all the people who need and desire relief from natural disaster in the province.

It is suggested that provincial leaders, agencies and donors consider the use of such models as an adjunct to their disaster mitigation strategies. It will not always be critical but it is suspected that wherever the study areas display the physical characteristics discussed in this paper, such an initiative should be contemplated for the direct and indirect benefits discussed above.

7. CAPACITY IMPROVEMENT THROUGH TRAINING IN MODELLING

The initial design of the QNNDMP took into account that advanced two-dimensional flood modelling was necessary in order to understand how the very large floodplains of the Central Region provinces behaved. Once the behaviour could be modelled for past events, including the devastating floods of 1998 and 1999, it was envisaged that the model could be used to demonstrate the impacts of future floodplain development, whether it be undertaken with a view to disaster management or not. This aspect of the project has proved to be extremely successful, not only for the engineering outcomes of the modelling for planning purposes but also as a medium by which provincial leaders and community groups can see and understand the implications via the modelling displays.

At the project design stage, it was accepted that Quang Ngai province did not have the capacity run such models and therefore once completed it was appropriate that capacity for such modelling was to be transferred to a national institute, the Institute of Water Resources Planning (IWRP). During the modelling phase of the project, technology transfer occurred through the counterpart involvement of a modelling engineer from IWRP and he has provided extension of this training back into IWRP.

Understandably modelling capacity in Quang Ngai was not high on provincial priorities at the time of the design because the benefits of state-of-the-art models were largely unknown and the technical hurdles for capacity building were not seen as justified compared with other needs. Demonstration of a successful outcome proved to be a much better impetus to capacity improvement than unproved instigation. As the value and efficiency of the current modelling become more obvious, it was clear that the opportunity of the project to enhance floodplain planning in a sustainable way through capacity building should be taken up.

Once this became clear, the provincial authorities submitted to AusAID that an additional element of the project should be undertaken to provide modelling capacity to the province. Within the existing budget, the AMC prepared a plan to train suitable candidates to a level of model users and modifiers. It was not anticipated that the training would take personnel to an advanced stage of new model development but all agreed that the existing development of models for the Tra Khuc and Tra Bong would enable the trained personnel to adapt them for ongoing planning purposes.

This activity was approved by AusAID and is being implemented. The province has shown commitment by allocating personnel full-time for the endeavour and AMC has undertake initial training courses and provided "on the job" modelling exercises for review during the next training sessions. The expected outcome will be of substantial impact for the sustainability of this component of the project and provides a model for other provinces with similar extensive floodplain and coastal planning issues.

8. SUSTAINABLE RISK MANAGEMENT CAPACITY

The QNNDMP design envisaged the development of floodplain management plans based on two dimensional modelling and agreed development guidelines. Further, it recognised the adoption of the agreed plans would require the incorporation of those outcomes into the instructional framework of the province in terms of master planning, approvals of development, approvals of agency works and, in general, the policy setting for management of the floodplain.

Until the project worked through the practical demonstration of floodplain planning implementation, it was not obvious how adoption of floodplain planning as recommended would be institutionalised. In developing the plan, the Project Management Board (PMB) adopted terminology that gave flexibility to the province to implement "through an appropriate implementation unit".

A signal of the successful partnership between the implementation team and the province is that the Provincial People's Committee (PPC) has consequently proposed a model that offers the strongest commitment to sustainable implementation.

The proposal by the PPC is that the prime implementation agency would be the existing provincial Flood and Storm Control Committee (FSCC). Further, implementation would involve extension of its current role by incorporating floodplain planning, and increasing its capacity to undertake its existing role in emergency management.

These roles are wrapped into the formal establishment of a Centre for the Management and Mitigation of Natural Disaster (CMMND) that under the proposal would be established as a permanent and year round body reporting to the PPC through its Vice-Chairman who heads the FSSC.

The CMMND would be the focal point for:

- Emergency planning and emergency management during natural disaster events
- Community based risk management training, education and consultation
- Use of the developed floodplain models for ongoing review of floodplain master planning, land use and development approvals

- Interaction with the Hydrometeorological service (HMS) on natural disaster preparation, warning and emergency management
- Inter–agency cooperation, training and consultation to agencies, district and consultation on disaster management
- Communication to agencies, district and commune leaders and the public on disaster management.

The proposal has been accepted by AusAID and is currently being implemented.

9. MODEL APPLICATION

It is worth noting some points on the actual application of the floodplain modelling for this NDM project. Two-dimensional hydraulic models were developed for the floodplains of the Tra Khuc/Ve River system and the Tra Bong River with these rivers constituting something more than half of the floodplains of Quang Ngai province. Since their implementation, the province has requested extension to cover the remainder of the provincial floodplains. AusAID has agreed on the basis that implementation will allow the establishment of the CMMND to be embedded with project support and is more likely to lead to a sustainable outcome.

On the subject of actual model implementation, the combination of model scale and data uncertainty posed a unique set of challenges for model development. New technologies, in the form of specialist software and GIS tools, were used to assemble the model from its component features in a way that retained the critical hydraulic characteristics.

The availability of a large number of spatially distributed recorded flood levels enabled the use of the automatic parameter optimisation routines to assist in the calibration process. This proved to be a useful tool to highlight deficiencies in the model and target areas for further refinement.

The ability of the model to generate impressive looking and easily understood output proved invaluable in the consultation processes for the development of the floodplain management plan. Despite the fact that stakeholders were initially unfamiliar with the concepts involved in floodplain planning, a good rapport and understanding was quickly developed while using the model to illustrate critical issues.

Design events were run over the range of 100 year ARI to 2 year ARI to map inundation for each event. The 100 year ARI peak inflows were estimated at 18,000 m^3/s, 4,800 m^3/s and 2,600 m^3/s on the Tra Khuc, Ve and Tra Bong rivers respectively. As examples, Figure 4 shows the depth and extent of flooding for a 100 year ARI event on the Tra Khuc floodplains. Figure 5 shows a hazard map generated from the product of depth and velocity. These were used to identify the major conveyance routes through the floodplain areas and to highlight problem areas and evacuation routes.

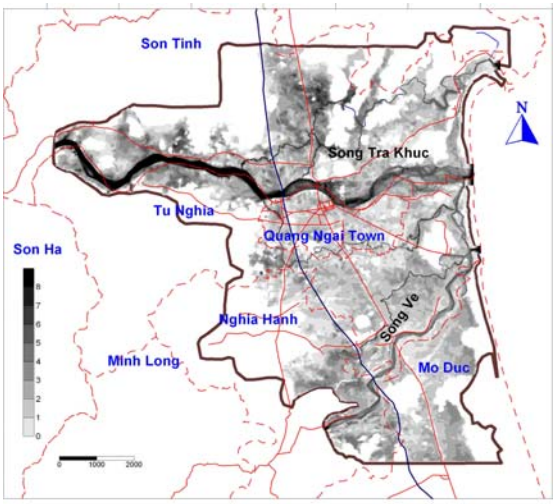

Figure 4 – Flood Depths and Extent of Flooding, Song Tra Khuc and Song Ve

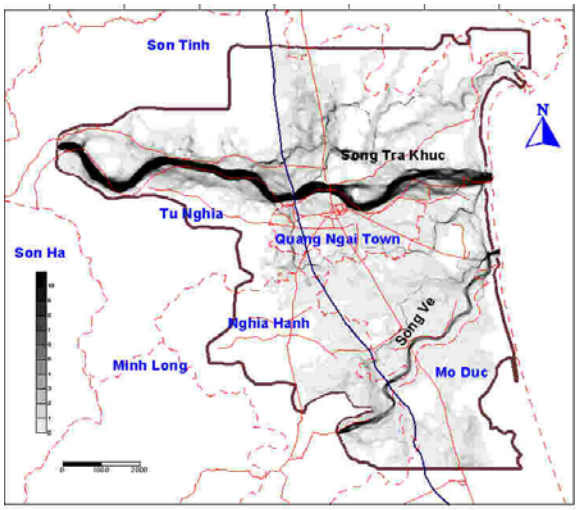

Figure 5 – Depth Velocity Product, Song Tra Khuc and Song Ve

Additional testing of "what if" scenarios was undertaken with the model to investigate a variety of development scenarios including floodplain filling, new road proposals and flood protection levees. Selected opportunities for flood improvement works were also investigated. Large scale flood improvement works proved not feasible, hence the emphasis in flood management was a philosophy of "living with floods": harm minimisation, and management planning to ensure existing problems are not unduly exacerbated, and that looming development in the floodplains and coastal environments does not lead to disasters of even worse magnitude than experienced to date.

The Tra Bong model was also used to undertake hydraulic design of anti-salinity dyke works in the lower estuary, and assess the impact of the escalating development of aquaculture ponds in the estuary waterways.

10. COMMUNITY INVOLVEMENT IN PLANNING ISSUES

The key issue for the management planning was to generate a sense of awareness in the government bodies and the general community that all activities in the floodplain and coastal estuaries are linked. These kinds of planning concepts are relatively new in an area which is developing rapidly. Communication was approached through a series of meetings with counterpart staff, and workshops with a wider range of stakeholders.

Despite some initial uncertainties, the general acceptance of planning concepts was quite encouraging. While not being insensitive to the hardships to some brought about by major flooding experienced during the course of the investigations, we were fortunate that this event fuelled the concept that structural works on the floodplain can have positive and negative impacts. In this instance, influential community people spoke publicly about perceived worsening of flooding in some areas following the construction of levee works in a different area.

Through the workshop process, the project was able to introduce concepts such as the retention of floodway conveyance and the importance of flood storage volume. By dividing workshop attendees into small groups and issuing questionnaires, feedback was received on issues such as acceptable levels of flood impact and desirable flood immunity for different types of new development. This feedback formed the basis for developing a plan which was consistent with local expectations.

A key feature in establishing credibility was having a two-dimension hydraulic model and being able to present the results and outcomes of the modelling in a way that was easily understood.

11. CONCLUSIONS

Implementation of NDM activity in developing countries, with a particular focus on poverty alleviation, can take many forms. This paper suggests that a very worthwhile form has the following ingredients:

- Integration of coastal and floodplain considerations for physical behaviour issues, institutional governance and structural, non-structural and community-based elements of the initiative
- Integration of structural, non-structural and community-based elements in the project design
- Development of medium and long-term planning as an essential tool to mitigate disasters in developing countries where development is occurring at a rapid rate
- Using advanced two-dimensional modelling as a focus for the planning effort and as a catalyst for political and community understanding and agreement
- Capacity development, through training of technical personnel and support of institutional arrangements for the management and mitigation of typhoon and flood impacts.

The rewards from this project will be on-going. Not only do the implementation outcomes provide lasting benefit to a community in need but the plans, the trained personnel and the established CMMND provide promise of a sustainable outcome. The potentially lasting benefits of this are critical in a country where more than 50% of the total population is affected in some way by typhoons and flooding.

12. ACKNOWLEDGEMENTS

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