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GREATER MEKONG SUBREGION ACADEMIC AND RESEARCH NETWORK (http://www.gmsarn.org)

The Greater Mekong Subregion (GMS) consists of Cambodia, China (Yunnan & Guanxi Provinces), Laos, Myanmar, Thailand and Vietnam.

The Greater Mekong Subregion Academic and Research Network (GMSARN) was founded followed an agreement among the founding GMS country institutions signed on 26 January 2001, based on resolutions reached at the Greater Mekong Subregional Development Workshop held in Bangkok, Thailand, on 10 - 11 November 1999. GMSARN is composed of eleven of the region's top-ranking academic and research institutions. GMSARN carries out activities in the following areas: human resources development, joint research, and dissemination of information and intellectual assets generated in the GMS. GMSARN seeks to ensure that the holistic intellectual knowledge and assets generated, developed and maintained are shared by organizations within the region. Primary emphasis is placed on complementary linkages between technological and socio-economic development issues. Currently, GMSARN is sponsored by Royal Thai Government.

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CONTENTS

Effects of Reclosing according to the Size of Distributed Generation

Hun-Chul Seo , Hyun-Soo Park, Sang-Min Yeo, Chul-Hwan Kim*

***Abstract*— *An autoreclosing is used for the purpose of restoring the power system after a trip of the circuit breaker. The successful autoreclosing can enhance stability and reliability of the power system. The distributed generation (DG) is the small and medium size generator connected to distribution system. Because of the efficiency and productivity of the DG, the integration of DG to the distribution system will be increasing. On the other hand, it may cause the many problems of power system. For example, the maloperation of protective relay by distributed generation may be occurred. This paper analyzes the effects of reclosing according to size of DG, and suggests adaptive reclosing algorithm considering DG. The proposed algorithm consists of angle oscillation's judgment, Emergency Extended Equal-Area Criterion (EEEAC), calculation of optimal reclosing time, and reconnection algorithm. The algorithm is implemented by ATP/EMTP-MODELS. The simulation results show that the transient stability is maintained and the distributed generation is protected against disturbance*.**

***Keywords*— Distributed Generation, Autoreclosing, EMTP, Transient Stability**

1. INTRODUCTION

Distributed generation (DG) is a small-scale generator such as wind turbine, fuel cells, and photovoltaic systems. DG is expected for next-generation energy source because of resources exhaustion and environmental problem recently.

The implementation of these generations may influence the technical aspects of distribution systems. The operation of DG can cause unwanted operation of protection and the fault level may be changed [1]. As the penetration level of DG becomes higher, the impact of DG on transient stability cannot be neglected.

The autoreclosing can recover distribution lines, transmission lines and circuit breakers which are damaged by electrical faults. The successful autoreclosing can enhance a transient stability and the reliability of power systems. However, the unsuccessful autoreclosing may cause the system unstable and the damage of system and equipment. The presence of distributed generation can cause the unsuccessful autoreclosing because the DG may sustain feeding fault current during the autoreclose open time prohibiting the intended arc extinction [1]. Therefore, references [1-2] suggest that the DG must be disconnected clearly before the reclosing. But, the frequent disconnection of DG may cause the decrease of power quality, such as outage and voltage sag. In addition, the reconnection after disconnection of DG may cause the secondary transients to distribution systems.

This paper presents the adaptive reclosing algorithm including angle oscillation's judgment, EEEAC, calculation of optimal reclosing time, and reconnection algorithm. The algorithm decides the disconnecting of DG by means of angle oscillation's judgment and EEEAC and then the autoreclosing is performed. The simulation is performed by ATP/EMTP MODELS, and the simulated results show the effectiveness of the suggested schemes. By employing the suggested algorithm, we can maintain transient stability and improve the power quality while the DG is protected against disturbances.

2. FAULTS IN DISTRIBUTION SYSTEM

After clearing the fault, the secondary arc current begins to flow at fault point by mutual coupling between fault phase and sound phase. If the autoreclosing is performed without asceratining precisely the secondary arc currnet extinction, the arc may be re-established. So the fault can become permanent and the power system can be unstable. Therefore, the secondary arc current extinction must be confirmed for the successful autoreclosing and power system stability.

There are two types of distribution systems. First, the DG can be connected to the loop type distribution system. In this case, because the fault point is isolated from the power system by operating circuit breaker at both terminals, the current supplied by DG does not flow at fault point. And the secondary arc current extinction depends on length of transmission line and system voltage. Second, the DG can be also connected to the radial type distribution system. After clearing the fault, the current supplied by DG continues to flow at fault point.

Figure 1 and 2 show the loop type and radial type distribution system, respectively [3]. The DG is modeled

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by synchronous generator in EMTP. And the arc model presented in [4] is used.

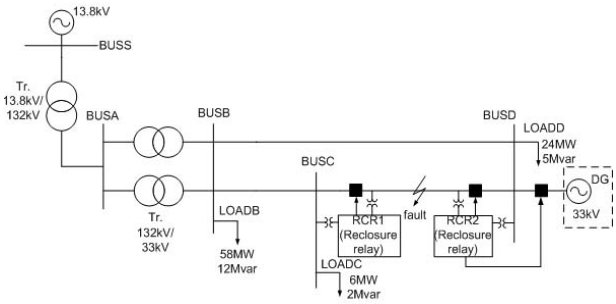

Fig. 1. Single-line diagram for loop type distribution system

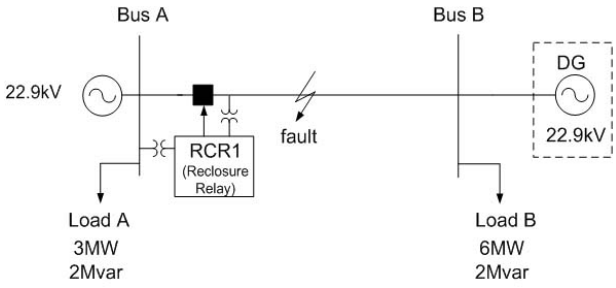

Fig. 2. Single-line diagram for radial type distribution system

Tables 1 and 2 show the system parameters for each type of distribution system, respectively.

Table 1. The system parameter for loop type system (Fig. 1)

From Bus	To Bus	Type	Resistance	Reactance
BUS S	BUS A	transformer	0	0.0667
BUS A	BUS B	transformer	0.0099	0.2088
BUS A	BUS B	transformer	0.0092	0.2170
BUS B	BUS C	line	0.0446	0.1917
BUS B	BUS D	line	0.2146	0.3429
BUS C	BUS D	line	0.2390	0.4163

Table 2. The system parameter for radial type system (Fig. 2)

From Bus	To Bus	Type	Resistance	Reactance
BUS A	BUS B	line	0.0446	0.1917

Figure 3 shows the secondary arc current extinction time according to size of DG in loop type distribution system. Figure 4 shows the secondary arc current extinction time according to size of DG in radial type distribution system.

In figure 3, we can find that the secondary arc current extinction time is not affected by the size of DG. As shown in figure 4, the secondary arc current extinction time may be affected by the DG size. However, the secondary arc current extinction time in figure 4 ranges from 0.0014s to 0.0016s, and these limits are very short. Therefore, we can conclude that the secondary arc current extinction time is not affected by the size of DG on radial type distribution network.

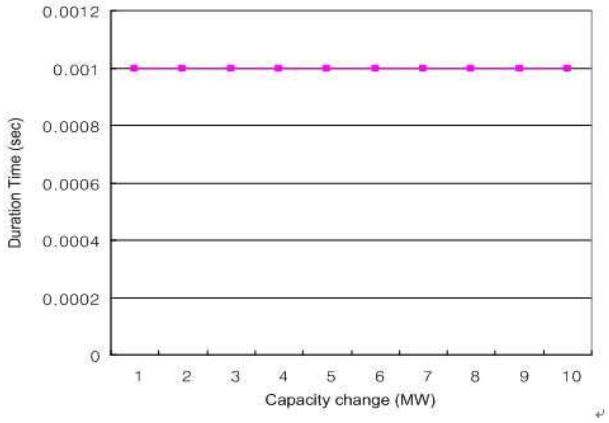

Fig. 3. Relation with duration time and capacity on loop type distribution network

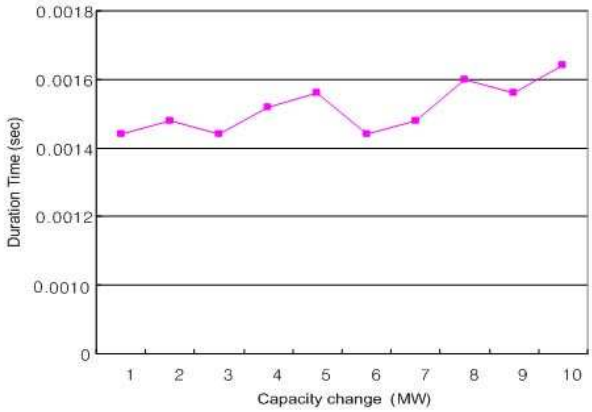

Fig. 4. Relation with duration time and capacity on radial type distribution network

Small-scale DG is linked to short distribution line length nowadays. In this case, the secondary arc current does not flow at fault point by neglecting the mutual coupling between the fault phase and sound phase. And the distribution system is more and more complex. Therefore, this paper supposes that 10MW DG is connected to the loop type distribution network.

3. AN ADAPTIVE RECLOSING TECHNIQUE WITH REFERENCE TO DISTRIBUTED GENERATION

Figure 5 shows the adaptive reclosing algorithms with reference to distributed generation. The impact of DG on power system transient stability depends on the technology of the DG. DG based on asynchronous

generator does not have much impact on transient stability, but DG based on synchronous generator has much impact on transient stability [5]. Therefore, in order to distinguish DG based on synchronous generator from DG based on asynchronous generator, the adaptive reclosing algorithm firstly judges whether the phase angle between two buses is oscillated or not after fault clearing (block 1). If angle oscillation is not occurred, the autoreclosing will be performed without disconnecting DG. If angle oscillation is occurred, the EEEAC (block 2) will be used to estimate the transient stability in real-time. In stable case, the reclosing is performed at optimal reclosing time by block 3 without disconnecting DG, whereas, in unstable case, the DG is disconnected to prevent the loss of synchronism and then the autoreclosing is performed and DG is reconnected at instant (Tr) calculated by reconnection algorithm(block 4) after successful autoreclosing. Blocks 2, 3 are presented in [6] and blocks 1, 4 are following.

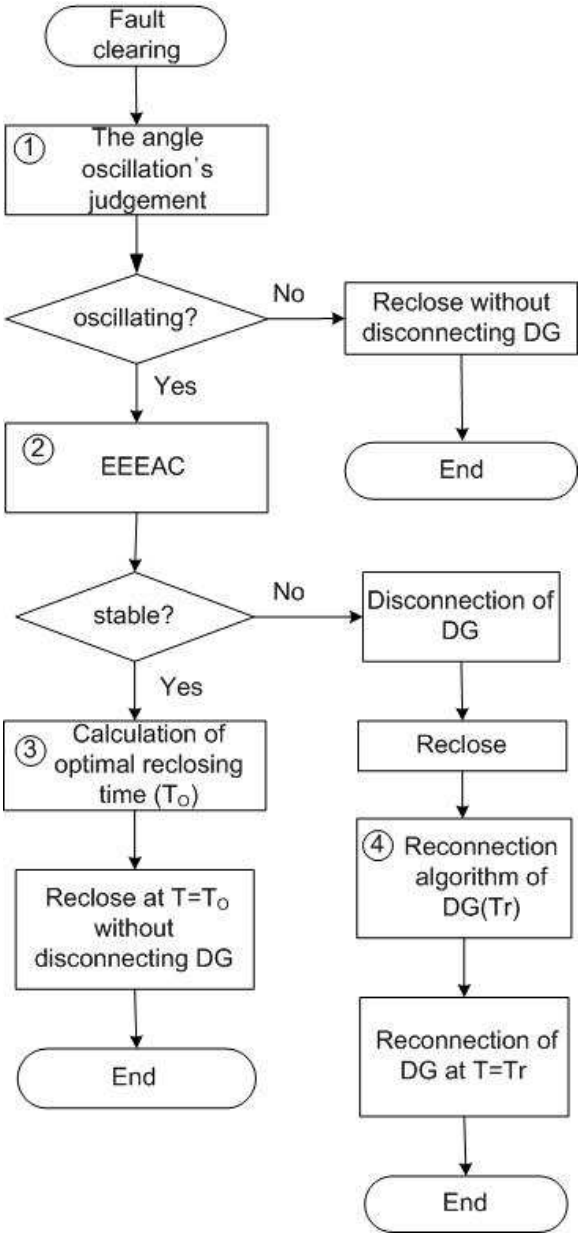

Fig. 5. The block diagram of adaptive reclosing algorithm

3.1 Angle oscillation's judgment

Figure 6 shows the phase angle oscillation's judgment method.

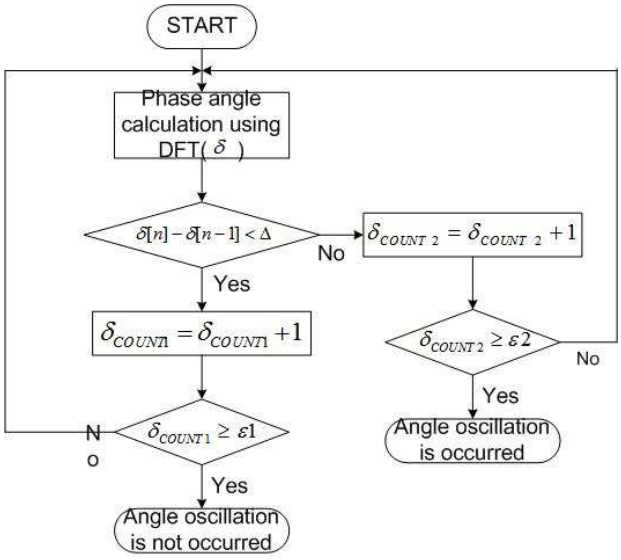

Fig. 6. The block diagram of angle oscillation's judgment method

The phase angle between two buses is calculated by using DFT. When difference-value between present phase angle and previous phase angle at each time step is less than Δ, where Δ is differential threshold that is used for judging the angle oscillation, δ_{COUNT1} is incremented.

Otherwise, δ_{COUNT2} is incremented. δ_{COUNT1} and δ_{COUNT2} are counter. If δ_{COUNT1} is greater than ε_1, angle oscillation is not occurred and if δ_{COUNT2} is greater than ε_2, angle oscillation is occurred. ε_1 and ε_2 are sample number.

The whole process is based on a moving window approach whereby a 1-cycle window is moved continuously by 1 sample and the sampling rate is 12 samples/cycle at 60Hz. The optimal setting for Δ, ε_1 and ε_2 are 0.01, 24 and 24, respectively.

3.2 The reconnection algorithm of DG

To prevent the instability of power system, DG is disconnected and then the autoreclosing is performed. In order to maintain reliability and safety of the distribution system, DG should be reconnected to the power system. The following is the KEPCO's rule for reconnection of DG.

- After recovery of power system disturbance, DG must be reconnected to the distribution system only if the power system voltage and frequency is maintained for five minutes in steady state.

Based on above rule, figure 7 shows the reconnection algorithm of DG.

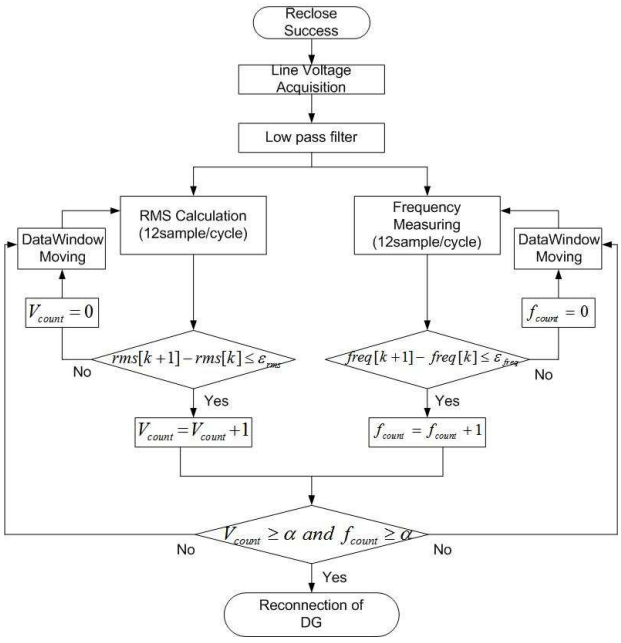

Fig. 7. The block diagram of reconnection algorithm

The RMS value of line voltage is calculated and the power system frequency is measured by using DFT. The algorithm is based on the difference-value between present value and previous value at each time step for voltage and frequency, respectively. If these difference-values are less than threshold, the power system is considered as steady state and then V_{count} and f_{count} are incremented. In figure 7, α is sample number, which means the steady state duration time. If the setting for α is 216,000, the steady state duration time is five minutes.

4. SIMULATION AND RESULTS

4.1 System model studied

The Electro-Magnetic Transient Program (EMTP) has been used for power system analysis under transient and dynamic conditions. It consists of a library of models of network components such as electrical machines, transformers, lines, etc. that can be interconnected together to simulate any required electrical network [7]. The reclosure relays are implemented through ATP/EMTP MODELS, which makes it possible to simulate the interaction between the power system and the relay [8].

Model system of distribution system for simulation is shown in Figure 1, which is interfaced with the reclosure relays (RCR1 and RCR 2 in figure1). The RCR2 controls the connection of DG as well as reclosing of circuit breaker. Model system has 5 buses, 3 transformers, and 3 loads. The uncoupled, lumped series branches by Type 0 in ATP/EMTP are used for distribution line.

The synchronous generator is modeled by Type 59 model. Double line to ground fault with duration of 0.167s is assumed on distribution line between BUS C and BUS D.

4.2 Simulation Results

4.2.1 When the proposed algorithm is not employed

Figure 8 shows the variation of the phase angle between two buses when DG based on synchronous generator is employed. In this case, although the synchronisms are lost as shown in figure 8, DG is not disconnected. As shown in figure 9, model system is unstable. The instability can be avoided by employing the suggested autoreclosing algorithm.

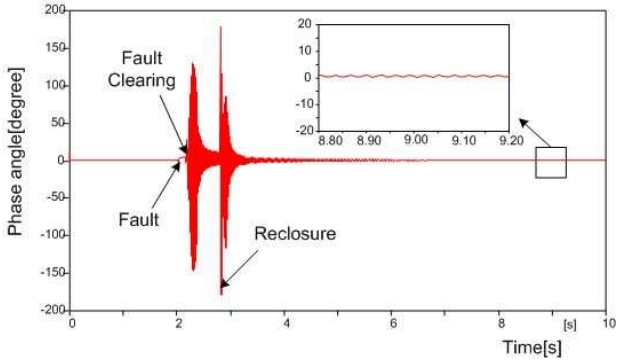

Fig. 8. Phase angle between two buses when DG based on synchronous generator is employed (The suggested algorithm is not employed).

4.2.2 When the proposed algorithm is employed

4.2.2.1 When the transient stability estimation by EEEAC is stable

Figure 9 shows the variation of the phase angle between two buses when DG based on synchronous generator is employed. After fault clearing, the angle oscillation is occurred so that the transient stability is assessed in real-time by EEEAC. In this case, the swing is stable, and hence the optimal reclosing time is calculated. The tripped line is reclosed 0.9s after the tripping of the circuit breakers. As shown in figure 8, the power system stability is maintained.

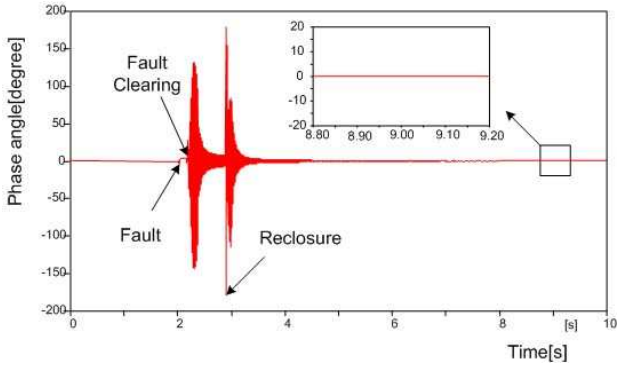

Fig. 9. Phase angle between two buses when DG based on synchronous generator is employed.

4.2.2.2 When the transient stability estimation by EEEAC is unstable

In unstable case, DG is disconnected by employing the suggested autoreclosing algorithm. The disconnection of DG unit causes a loss of generating sources, which leads to power quality drop and changes of protection settings. Therefore, DG has to be reconnected to the power system as soon as possible.

In this paper, the reconnection time based on KEPCO's rule and the faster reconnection time are simulated, and simulation results are analyzed. To compare the reconnection time based on KEPCO's rule with the faster reconnection time, two indicators, i.e. maximum deviation and oscillation duration, have been applied to the oscillations of the frequency and phase angle between two buses after reconnection of DG. The setting of faster reconnection time is assumed 5s, which is implemented by setting 3,600 at α in figure 7.

1) Frequency

Figures 10 and 11 depict, respectively, the frequency variation when the reconnection time (five minutes) based on KEPCO's rule and the faster reconnection time (five seconds) is applied. Table 3 shows the maximum deviation and oscillation duration after reconnection of DG. Two cases have an equal duration time, while the maximum deviation of reconnection time based on KEPCO's rule is greater than it of faster reconnection time, as shown in table 3.

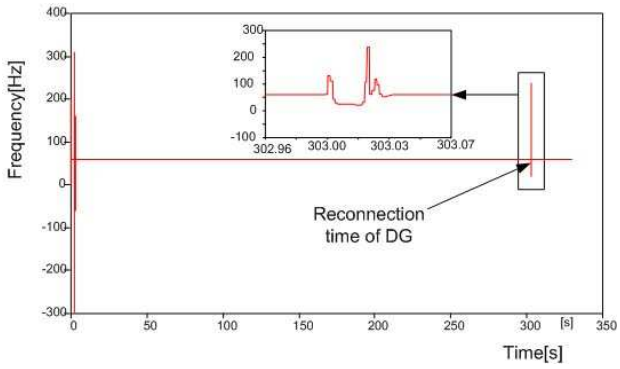

Fig. 10. Frequency variation when the reconnection time based on KEPCO's rule is applied.

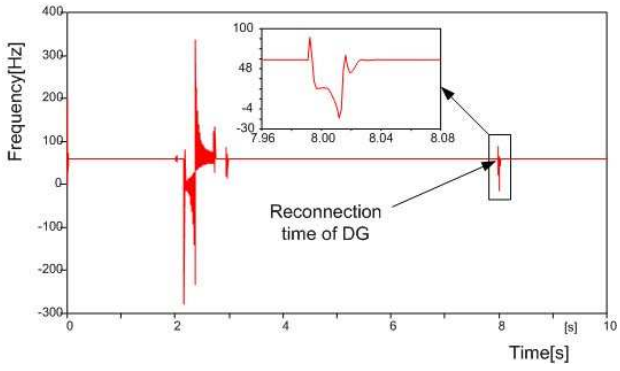

Fig. 11. Frequency variation when the faster reconnection time is applied.

Table 3. Maximum deviation and oscillation duration of frequency

Indicator / Reconnection time	Maximum deviation	Oscillation duration
Five minutes	218Hz	0.035s
Five seconds	104Hz	0.035s

2) Phase angle between two buses

Figures 12 and 13 depict, respectively, the phase angle between two buses when the reconnection time (five minutes) based on KEPCO's rule and the faster reconnection time (five seconds) are applied. Table 4 shows the maximum deviation and oscillation duration after reconnection of DG. Two cases have an equal duration time, while the maximum deviation of reconnection time based on KEPCO's rule is greater than it of faster reconnection time, as shown in Table 4.

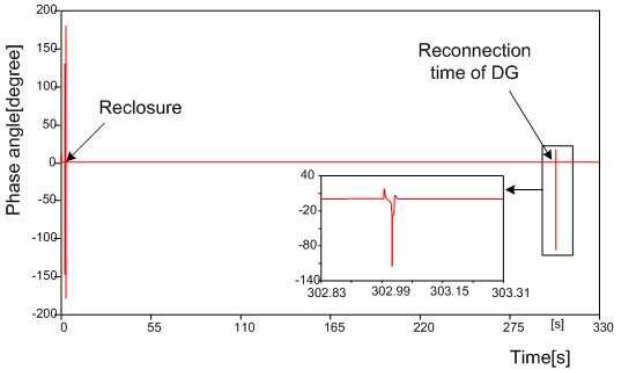

Fig. 12. Phase angle variation between two buses when the reconnection time based on KEPCO's rule is applied.

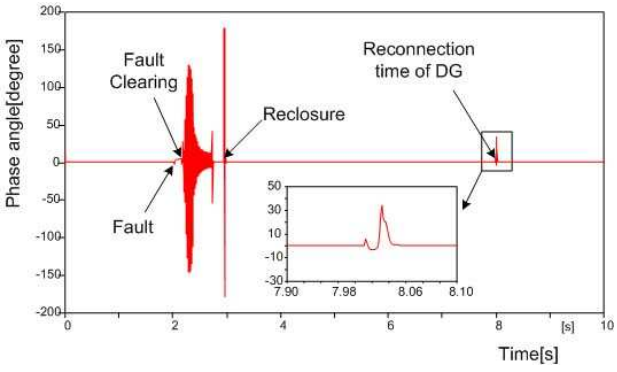

Fig. 13. Phase angle variation between two buses when the faster reconnection time is applied.

Table 4. Maximum deviation and oscillation duration of phase angle variation between two buses

Indicator / Reconnection time	Maximum deviation	Oscillation duration
Five minutes	132°	0.05s
Five seconds	22.5°	0.05s

4.2.2.3 Discussion

As shown in tables 3 and 4, oscillation duration is equal, while maximum deviation for case of five seconds is less than maximum deviation for case of five minutes. These results support that the reconnection time of five seconds is more efficient. Therefore, in the reliability and safety point of view, DG has to be reconnected at the faster time than reconnection time based on KEPCO's rule if possible.

5. CONCLUSIONS

This paper has presented an adaptive autoreclosing technique with reference to distributed generation for improving and maintaining the system stability. The proposed autoreclosing technique is composed of four blocks, i.e. the angle oscillation's judgment, calculation of optimal reclosing time, EEEAC and reclosing algorithm. The proposed autoreclosing algorithm is verified and tested for distribution system with DG, namely synchronous generator.

The simulation results show that the transient stability for all cases is maintained by using proposed autoreclosing technique. Specially, when DG unit is disconnected, it is verified that reconnection of DG needs to be performed faster than the reconnection time based on KEPCO's rule. The adaptive autoreclosing technique presented herein can be useful in protection and efficient operation of DG.

Although the development on DG, e.g. wind turbine, fuel cells, and photovoltaic systems grows significantly, the penetration of DG is still low in KEPCO's system. If increasing amounts of DG is connected to electrical power systems by growing concern over CO_2 emissions and technological developments, the interest on reclosing for power system protection will be also increased. Moreover, in the future, the KEPCO's distribution system will become the complex system that has many short distribution lines, various loads, and generation sources. In this trends, the suggested reclosing algorithm better than current KEPCO's rule will have the potential for application in KEPCO's system.

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REFERENCES

[1] L. K. Kumpulainen, K. T. Kauhaniemi. 2004. Analysis of Impact of Distributed Generation on Automatic Reclosing. Power Engineering Society Winter Meeting, 2004 IEEE PES. 1: 603-608.

[2] IEEE Power Engineering Society: IEEE Guide for Automatic Reclosing of Line Circuit Breakers for AC Distribution and Transmission Lines.

[3] S.M. Yeo, C.H. Kim. 2003. Analysis of System Impact of the Distributed Generation using EMTP with Particular Reference to Protection Strategies. IFAC Symposium on Power Plants & Power System Control, Korea, Sep: 897-902.

[4] S.P Ahn, C.H Kim, R.K. Aggarwal, A.T. Johns. 2001. An alternative approach to adaptive single pole auto-reclosing in high voltage transmission systems based on variable dead time control. IEEE Trans. on Power Delivery 16(4): 676-686.

[5] J.G. Slootweg, W.L. Kling. 2002. Impacts of Distributed Generation on Power System Transient Stability. Power Engineering Society Summer Meeting, IEEE. 2: 862-867.

[6] Jeong-Yong Heo. 2002. A study on the Algorithm of Auto-reclosing with reference to Power System Stability. Sungkyunkwan University Master's Thesis.

[7] Salman K. Salman, Ibrahim M. Rida. 2001 Investigating the Impact of Embedded Generation on Relay Setting of Utilities' Electrical Feeders. IEEE Trans. On Power Delivery 16(2): 246-251.

[8] C. H. Kim, M. H. Lee, R. K. Aggarwal, A. T. Johns. 2000. Educational Use of EMTP MODELS for the Study of a Distance Relaying Algorithm for Protecting Transmission Lines. IEEE Trans. on Power System 15(1): 9-15.

Trans-boundary Environmental Impact Assessment of Hydroelectric Resources Exploitation in Multi-Jurisdictional River: A Case Study of the Lancang-Mekong River

Li Xikun and Shu Min*

Abstract— *This article focuses on one of the most effective ways to manage trans-boundary environmental problems caused by multi-jurisdictional river exploitation – trans-boundary environmental impact assessment (TEIA) – how it can be used to realize rational exploitation of hydroelectric resources in Multi-jurisdictional River, to promote sustainable development, and how it can work in the case of the Lancang-Mekong River.*

***Keywords*— hydroelectric resources exploitation, Lancang-Mekong River, trans-boundary environmental impact assessment**

1. INTRODUCTION

At 4,909 kilometers, the Lancang-Mekong River is the world's 10th-longest and 8th-highest river. From a source of approximately 5200 m above sea level in the Tanggula Mountains on the Qinghai-Tibet Plateau [1], the Lancang-Mekong River flows 2190 kilometers through China's southern provinces of Qinghai and Yunnan, and then it flows a further 2719 kilometers through Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. During this journey, the downstream Mekong first forms the boundary between Myanmar and Lao PDR, and then the boundary between Lao PDR and Thailand. After turning into the south territory of Lao PDR, the river again forms the boundary between Lao PDR and Thailand. Then, it flows into Cambodia. Here the downstream Mekong connects with Cambodia's Great Lake the Tonle Sap Lake through the Tonle Sap River. At last, the river flows into the Mekong delta of Vietnam where it pours out into the South China Sea.

As the most famous river system in Asia, hydropower resources have been regarded as the most important resource of the Lancang-Mekong River. This river has a massive drainage area of about 795,000 square kilometers, with an annual discharge of approximately 475, 000 million cubic meters and total water power reserves of around 90 million kW across six countries. For example, the Upper Mekong, which is known as the Lancang River of China, is mostly turbulent in the cataracts and gorges, with theoretical reserves of hydro energy of about 36.56 million kW. The Lan-cang River is estimated to have a capacity to generate 320.3 billion kWh of hydropower electricity annually [2].

From 1957 to 1970, hydro projects within the Subregion, which altogether were estimated to be able to generate 2.5 million kW of hydropower and to irrigate over 0.5 million hectare areas, had been completed over the Lancang-Mekong River. From 1971 to 1980, in Thailand, Lao PDR, Cambodia, and Vietnam, other hydroelectric power engineering projects which could totally provide over 3.27 million kW of electricity had been finished [3].

Up to now, there have been established three main Lancang-Mekong River development cooperation systems. The Mekong River Commission (MRC) was established formerly in 1950's and reorganized by the 1995 Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin. The other two are Greater Mekong Subreign Cooperation (GMS) implemented in 1992 and ASEAN—MEKONG Basin Development Cooperation (AMBDC).

More recently, countries along the Lancang-Mekong River has taken hydroelectric resources exploitation in this river as a very important way to lift their citizens out of poverty and backwardness, to develop industry and technology, and to revitalize the economy. Simultaneously, various environmental problems, especially trans-boundary environmental problems emerge during the exploitation process have been becoming a cause for world concern. Therefore, this article focuses on one of the most effective ways to manage trans-boundary environmental problems caused by multi-jurisdictional river exploitation – trans-boundary environmental impact assessment (TEIA) – how it can be used to realize rational exploitation of hydroelectric resources in Multi-jurisdictional River, to promote sustainable development, and how it can work in the case of the Lancang-Mekong River.

2. ENVIRONMENTAL IMPACT ASSESSMENT

An environmental impact assessment (EIA) is a report or evaluation of the likely or possible human environmental health impacts and ecological health impacts that a project or proposed activity may have. The purpose of this procedure is to ensure that the environmental impacts of decisions are taken into account by decision-makers before the decisions are made. During the process of EIA, the public is supposed to participate in decision-making and give their opinions towards the project or proposed activity.

According to the UNEP Environmental Impact

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Assessment Training Resource Manual, an EIA usually begins with the proposal of a project or a proposed activity which may have environmental impacts. Then it comes into the "screening" step, in which it must be determined whether an EIA is necessary for this relevant project. The output from the screening process is often a document called an Initial Environmental Examination / Evaluation (IEE). This is usually a preliminary assessment of whether the project has potentially significant environmental impacts. If it has or it has been legislated that an EIA is necessary, then an EIA is required [4].

For project or proposed activity in which an EIA is required, the party has to submit relevant EIA documents to illustrate what kind of environmental, as well as social , economic, and cultural issues should be considered and which alternatives should be included in the EIA. This is so-called "scoping" process. In this process, the public is supposed to participate into providing opinions and suggestions for possible significant environmental impacts and other kinds of impacts of relevant projects. Theoretically, these opinions and suggestions are considered to be very important and essential for decision-making. Moreover, scoping is perhaps the most important step in an EIA. It is important for two reasons. First, it helps to pinpoint problems early, allowing mitigating design to be made before expensive detailed work is carried out. Second, it helps to ensure that detailed prediction work is only carried out for important environmental issues. If key issues are identified and a full scale EIA considered necessary then the scoping should include terms of reference for further studies. Equally it may be the end of the EIA process once the impacts are found to be insignificant.

In the following draft Environmental Impact Statement (EIS) process, further prediction, investigation, and analysis works start. These works includes formal collection of data and materials to identify or evaluate possible or potential environmental impacts, as well as other social, economic, and cultural effects and their alternatives. Besides the professional and technical advice given by institutions of government, experts, and other authorized agencies or horizontal researching organization, public input are also considered to be significant. According to the UNEP Environmental Impact Assessment Training Resource Manual, methods of public participation include hearing of assessment, investigation, questionnaire, and so on. After examined by government agencies and the public, a final EIA is well prepared. Although the final EIA may not decide by itself whether to approve or deny the relevant project or proposed activity, it is a very important tool and judgment basis for government and decision-makers to decide whether to approve, deny, or approve conditions original project or proposed activity.

In order to make the most of the experience and knowledge gained, the last stage of an EIA is to carry out an Environmental Audit sometimes after completion of the project or implementation of a program. The audit includes analysis of the technical, procedural and decision-making aspects of an EIA. Lessons learned and formally described in an audit can be very helpful in future EIAs and building up the expertise and efficiency of the concerned institutions.

The most significant difference between EIA and Trans-boundary Environmental Impact Assessment (TEIA), or we could say the greatest obstacle to realize TEIA is that TEIA involves international and trans-boundary elements. This may cause problems rising in international cooperation, national security for specific countries, state sovereignty, and international democracy. Other problems like language obstruction, trans-boundary public participation, and differences or handicaps existing in different countries' environmental standards may occur as well [5].

3. POTENTIAL ENVIRONMENTAL IMPACTS OF HYDROELECTRIC RESOURCES EXPLOITATION IN THE LANCANG-MEKONG RIVER

Up to now, the hydroelectric resources exploitation in the Lancang-Mekong River has quite satisfied Southeast Asian countries' needs for electricity power. However, at the same time, various environmental and other kinds of impacts and problems are getting more and more obvious.

Dam constructions have changed minimum discharge of the Lancang-Mekong River, which may cause climate change and influence the ecosystem. Figures collected from 2004 UN Symposium on Hydropower and Sustainable Development shows that during 1962-1992 the minimum discharge of the Mekong on Thai-Lao border was 752 CMS (Cubic Meter per Second); however, during 1993-2003, after the construction of Manwan dam across the Lancang River in China, the minimum discharge on Thai-Lao border has decreased to only 569CMS (Cubic Meter per Second) [6].

The irrational hydroelectric exploitation has also ruined the biodiversity of the Lancang-Mekong River Baisn and made significant changes to the ecosystem of the Lancang-Mekong River. For example, as most kinds of fish in this river are migratory species, they have to migrate to the upstream for reproduction depending on annual river flow. Therefore, the water fluctuation caused by dam construction inevitably results in a great decline of fish, which means a great decrease in food security for local people as well as the disruption of riparian countries' economic and social structures. The 136 MW Pak Mun Dam, which was completed in 1994, was built by the Electricity Generating Authority of Thailand with US$24 million in financing from the World Bank. This hydroelectric dam is located near the mouth of the Mun River, the largest tributary of the Mekong River which runs through Ubon Rachathani, a northeastern province of Thailand. According to the World Commission on Dams' study in 2000, of the 265 fish species recorded in the Mun River watershed before 1994, 77 species were migratory and 35 species are dependent on habitat associated with rapids. However, the latest survey recorded just 96 species in the upstream region of this river. Out of 169 species which has not been found in the present catch, at least 50 species of rapid dependent fish have disappeared. Over 51 species

have been caught less significantly since the completion of the Pak Mun Dam, and the families of many species greatly declined. The fish catch directly upstream of the dam has declined by 60-80% after the completion of the project [7]. The rapids in the river, where the migratory fish used to lay their eggs, were destroyed. The fish ladder which had been installed to help the migratory fish is criticized by the local villagers as being completely ineffective. Furthermore, the original number of household to be displaced for the dam was originally said to be 262 families, but in reality, 912 households have already been relocated, 780 of which have lost all or parts of their land. In addition, there are more then 2500 families who are protesting against the damage to their fisheries.

In addition, the long-term economic benefit of hydroelectric construction has also been considered to be over exaggerated. A report made by Probe International in Canada lists ten reasons why the World Bank should not finance the Nam Theun 2 Power Company in Lao PDR. Among all those reasons, "proponents have failed to demonstrate Nam Theun 2 economic viability" has been listed on the top [8].

Due to fact that the Lancang-Mekong River itself is a living ecosystem, environmental impact towards this river can not be caused by only one country. Any significant environmental impacts, as well as social, economic, and cultural impacts happen in one country will influence other riparian countries remarkably or potentially. Therefore, it is necessary for us to develop a rational and sustainable structure of hydroelectric resources exploitation in this river. A sound framework of Trans-boundary Environmental Impact Assessment which can help to prevent irrational resources exploitation and to reduce significant trans-boundary environmental impacts from happening is an effective way for constructing such a sustainable hydropower resources development structure.

4. INTERNATIONAL AND REGIONAL PRACTICES AND CONVENTIONS OF TEIA

Sources of Law: International Law and Conventions

Although principles of the EIA system has been developed and adopted by both international environmental agreements and national laws of specific countries, the TEIA process is not yet well-developed. In the past few decades, the international society has taken great efforts to realize the construction and establishment of the TEIA process, especially the TEIA in international watercourse and trans-boundary freshwater. Treaties, conventions, and agreements have been signed and put into force. International organizations such as United Nations Environment Programme (UNEP), the Organization for Economic Cooperation and Development (OECD), and the World Bank have addressed issues of the TEIAs and endeavored to push forward the construction of a sound frame of the TEIA process. These treaties, conventions, agreements, and documents are the direct sources of law of the TEIA system.

Early in the Principle 21 of the 1972 Stockholm Declaration has provided that "States have, in accordance with the Charter of the United Nations and the principles of Environmental law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction." This could be regarded as one of the earliest international source of law for the TEIA system. Other recent international Conventions such as the 1992 Convention on Biological Diversity (CBD) [9] and the 1982 United Nations Convention on the Law of the Sea (UNCLOS) [10] also clearly mandate to invoke the TEIA process into relevant trans-boundary projects or national proposed activities which may have trans-boundary or international impacts.

Usually, the TEIA process is used for special projects or proposed activities which may have significant adverse trans-boundary or international environmental impacts. Examples are projects which may have great adverse trans-boundary effects on biodiversity, marine areas, and freshwater systems. The United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses of 1997 establishes and approbates a relatively complete system of TEIA for trans-boundary freshwater areas, which includes the basic principles and concepts of the TEIA process, as well as notification, exchange of technical data and information between relevant countries. Article 12 "Notification Concerning Planned Measures with Possible Adverse Effects" of this Convention enacts: "Before a watercourse State implements or permits the implementation of planned measures which may have a significant adverse effect upon other watercourse States, it shall provide those States with timely notification thereof. Such notification shall be accompanied by available technical data and information, including the results on any environmental impact assessment, in order to enable the notified States to evaluate the possible effects of the planned measures."

Regional Practices and Conventions of TEIA

European and North American countries have commonly adopted regional agreements or conventions that provide regulations of the TEIA process. In the past years, Western Europe has made great contribution all along to the TEIA system construction. In 1985, the European Community adopted a Council Directive on the assessment of the effects of certain public and private projects on the environment. The Directive included a few general provisions that could apply to trans-boundary effects [11].

On the basis of the Council Directive, and taking into account work on environmental impact assessment carried out under the auspices of the United Nations Economic Commission for Europe (UNECE), three conventions focus mainly on protection and the TEIA system of trans-boundary watercourses are adopted and open for signature in Europe. These conventions are UNECE Convention on the Protection and Use of

Transboundary Watercourses and International Lakes (the Helsinki Convention), the Convention on the Environmental Impact Assessment in a Trans-boundary Context (the Espoo Convention), and the Convention on Access to Information, Public Participation and Access to Justice in Environmental Decision-making (the Aarhus Convention).

North America has a longer EIA history; however, its experience on the TEIA system is not as rich as that of Europe. The TEIA process of trans-boundary watercourse in North American has been mainly established upon settlements of problems occurring in the trans-boundary rivers and lakes, such as the Columbia River and the North American Great Lakes, between the United States and Canada. In North America, the basic international framework addressing TEIA is the North American Agreement on Environmental Cooperation (NAAEC), which was signed by Canada, the United States, and Mexico and entered into force on January 1, 1994 as a sub international environmental cooperation agreement of the North American Free Trade Agreement (NAFTA), and the North American Commission on Environmental Cooperation (NACEC) established by NAAEC. The NAAEC is an agreement focuses on the notification of relevant information and consultation between parties during the TEIA process, and on the mitigation of potential adverse effects of proposed projects which are likely to have significant adverse trans-boundary impacts [12]. Later in June 1997, another TEIA agreement "Trans-boundary Environmental Impact Assessment Agreement (TEIAA)" has been drafted by Canada, the United States, and Mexico.

Practices of TEIA to the Lancang-Mekong River

Although there are no specific regional conventions and agreements on the topic of the TEIA system in the Lancang-Mekong River, we do have some experience on this issue. On the one hand, almost all of the riparian countries of the Lancang-Mekong River have their respective domestic law on EIA (not TEIA) no matter specifically or sweepingly. On the other hand, in 1995, Cambodia, Lao PDR, Thailand, and Vietnam has signed the Agreement on the Sustainable Development of the Mekong River Basin which requires the riparian nations to provide timely notification and consultation prior to implementing any projects using the river. This agreement is not a direct regional document but emphasizes on the TEIA process, and also provides regulations which are very similar to the requirements of constructing TEIA system. Moreover, international organizations such as the MRC and the GMS also take great efforts to push forward the monitoring and auditing organisms of trans-boundary impacts and pollutions, as well as to establish general structure of TEIA. NGOs also play important roles in this process.

5. CONSTRUCTION OF TRANS-BOUNDARY ENVIRONMENTAL IMPACT ASSESSMENT OF HYDROELECTRIC RESOURCES EXPLOITATION IN THE LANCANG-MEKONG RIVER

To discuss on this topic, we have to above all nail down some of the premise problems. First, the TEIA process is supposed to do with the problem of trans-boundary environmental impacts which includes trans-boundary pollution. However, trans-boundary pollution just presents one distinct and visible aspect of trans-boundary environmental impacts and trans-boundary environmental impacts mean much more than trans-boundary pollution. Then, what is the nature of trans-boundary environmental impacts? This question has always been an obstacle of practicing TEIA. Article 1 of Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes defines trans-boundary impact as "any significant adverse effect on the environmental resulting from a change in the conditions of trans-boundary waters caused by a human activity, the physical origin of which is situated wholly or in part within an area under the jurisdiction of a Party, within an area under the jurisdiction of another Party. Such effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape, and historical monuments or other physical structures or the interaction among these factors; they also include effects on the cultural heritage or socio-economic conditions resulting from alterations to those factors; " The Espoo Convention on the Environmental Impact Assessment in a Transboundary Context states trans-boundary impact as "any impact, not exclusively of a global nature, within an area under the jurisdiction of a Party caused by a proposed activity the physical origin of which is situated wholly or in part within the area under the jurisdiction of another Party" [13].

Any trans-boundary environmental impact, not necessarily to be globally, which needs TEIA is usually supposed to be significant adverse impact that may influence two or more countries. Thus, before practicing the TEIA process, we need at least to know what kind of projects or proposed activities, include projects and proposed activities on the hydroelectric resources exploitation, in the Lancang-Mekong River are considered to have significant adverse trans-boundary environmental impacts. This list comes from two origins. One is provisions laid down by regional conventions or agreements, which identify the specific projects and proposed activities that are considered to have significant adverse impacts and need TEIA. Another origin is opinions come from different national governments and the public, as well as NGOs and other organizations that are able to give correct judgments [14].

Notification and Screening

The absence of a regional convention or agreement on TEIA in the Lancang-Mekong River is an obvious gap in the trans-boundary environmental management in this river. Before we have such a convention, any origin country for a proposed activity that includes hydroelectric resources exploitation activity, which is likely to cause a great trans-boundary environmental impact in the Lancang-Mekong River, in its river basin,

and in the environment of the riparian countries, shall notify any riparian country (that is considered to be an affected country) and provide relevant information as early as possible about the nature and possible impacts of this activity to ensure adequate and effective investigation and consideration are made.

Then it follows the next step which is similar to EIA's screening. The potentially affected countries shall, according to the information and materials provided by the origin country, initiatively investigate and research the possible impacts they may suffer, notify and consult their citizens and public; provide their position on the necessity of the TEIA and suggestions, along with reasonable evidence and data, to the origin country.

Subject Party to Submit TEIA

The subject responsible for submitting the TEIA of hydroelectric resources exploitation, i.e. who is going to initiate and prepare the TEIA documentation, is generally the origin country for the proposed activity. The specific party to take over this work could be the national government or authorized agency. In some particular cases, the TEIA may be prepared by NGOs, IGOs, and other trans-state actors.

Scoping

Scoping stage in TEIA occurs before the drafting of a formal TEIA document when the relevant countries commonly agree that a TEIA is necessary for the proposed hydropower exploitation project based on a preliminary determination made from the notification and screening process. Scoping is the process of determining which are the most critical issues to study and further research into, and will involve riparian countries / public participation to some degree. It is at this early stage that TEIA can most strongly influence the outline proposal. This stage includes a deeper investigation and assessment of factors and alternatives that need to be considered in the TEIA document.

A major activity of scoping is to identify key interest groups, both governmental and non-governmental, of the possible affected countries. The public, especially people or communities who are affected shall be encouraged to express their attitudes, comments, and suggestions to the project. Consultation and public participation are considered to be essential, especially for hydroelectric resources exploitation projects in the Lancang-Mekong River for they may have ad hoc significant adverse trans-boundary environmental impacts. In this situation, public participation in different jurisdictions can be conducted by different countries and their governments.

The main techniques used in scoping are baseline studies, checklists, matrices, and network diagrams. These techniques collect and present knowledge and information in a straightforward way so that logical decisions can be made about which impacts are most significant.

Different countries and areas have different experiences toward the scoping process of TEIA. In Europe, the consideration of alternatives is a central focus of the scoping stage [13]; while other countries such as Netherlands, Canada, and Denmark have ruled the requirement of consultation and public participation at the scoping stage by regulation; countries such as the United States emphasize the recommendation and broad consultation practice and public participation, though not required.

Preparation of the TEIA Documentation

Any TEIA documentation of hydroelectric resources exploitation projects or proposed activities shall basically contain a description of the nature and characteristics of the project or proposed activity, and its purpose; possible alternatives; and the environment that is likely to be affected and its possible or potential environmental impacts. Also included in the documentation are other uncertainties that result from gaps of knowledge or lack of technologies; mitigation measures which can be taken to control the adverse environmental impacts; and suggestions whether to proceed with the projects or not. Conclusion and suggestions of the TEIA on whether to approve, deny, or approve with conditions original project or proposed activity shall be made with discretion according to reasonable and adequate data, references, materials, as well as maps and graphs collected from all relevant countries and areas. The Espoo Convention can be used for reference in this part.

Consultation and Public Participation after Distribution of the TEIA Documentation

The key to realize this step is to figure out when, how, to whom, and in what languages to carry out the public summons of the TEIA documentation. After the preparation of the TEIA documentation, the origin country shall provide the documentation to people and communities which likely to be affected by the project or proposed activity. The origin country shall also provide possible affected countries with the TEIA documentation in the affected countries' respective languages or in a generally used language no later than informing its own public. The concerned countries shall distribute the documentation to relevant national authorities and their people who may be affected or living in the affected areas according to their domestic laws.

After the distribution of the TEIA documentation, specific countries shall arrange the third round of consultation and public participation. In this round, people and the public to be affected in relevant countries have right to know possible alternatives for relevant hydroelectric exploitation projects, mitigation measures which would be taken, and at what expense. They also have right to express their own experiences and opinions on if the TEIA documentation is efficient enough and their attitude whether to approve or deny the proposed activity.

In the whole process of TEIA, governments of origin country and other affected countries shall guarantee the democracy and equality of public participation to ensure that the public and people in the areas likely to be affected to give their own and true concerns and

comments.

In order to ensure that people who may be affected by a proposed hydroelectric resources exploitation project or activity have an equal opportunity to voice their concerns, we suggest riparian countries to promote either harmonization or nondiscrimination, which essentially is an equitable safeguard ensuring that all affected people to have equal opportunity to participate in environmental decision-making.

Final Decision

As we have discussed before, the greatest obstacle to realize TEIA is that TEIA involves international and trans-boundary elements. Therefore, the process or result of TEIA may cause problems rising in international cooperation, national security for specific countries, state sovereignty and so on. In order to settle these problems, we must fully understand that the Lancang-Mekong River is first a multi-jurisdiction river. Different reaches of this river belong to different countries and different state sovereignty. To carry out a specific hydroelectric resource exploitation project or not is first the origin country's domestic affair. Thus, efforts to promote international and regional cooperation must be ensured to guarantee that no national security may be infringed, and therefore achieve international justice and equality.

The final decision of a TEIA process may be to approve, deny, or approve with conditions the proposed project or activity pursuant to the outcome of TEIA documentation.

Post Decision-making Analysis and Cooperation

If the final decision has been made to approve or approve with conditions the proposed project or activity, then further post decision-making work such as monitoring and analysis should be executed based on the cooperation of all relevant countries throughout the whole process of project construction and afterwards. Once any new potential significant adverse environmental impacts, which have never been noticed or have been listed as uncertainty during the former TEIA process, have been discovered, such information shall be immediately notified to the origin country, and if necessary, the undertaking project shall be stand-down and new TEIA or other emergent measures shall be taken.

6. BRIEF CONCLUSION

In the past few decades, various countries and regions have endeavored to establish a sound framework of TEIA and great experiences have been gained. However, the TEIA system has not been formally and officially practiced in the Greater Mekong Subregion and in the management of the Lancang-Mekong River. In the future, more work is needed for establishing such a frame, as well as seeking for stable financial resources to practice the TEIA, as well more efforts should be taken to reduce and dilute the unjust political factors and characteristics which may be adulterated to the TEIA process. The legality of TEIA system and conventional means of relief for disputes should be further and broadly explored.

REFERENCES

[1] Liu Shaochuang; Lu Pingli; and Liu Donghui. 2007. Pinpointing source of Mekong and measuring its length through analysis of satellite imagery and field investigations. *Geo-Spatial Information Science* 31: 51-56.

[2] Huang Guangchen. 2004. *The Lancang River & the Nu River*. Baoding, China: Hebei University Press.

[3] Wang Xiaoming. 2001. The Environmental Impact of Hydroelectric Resources Development of the Mekong. *Southeast Asian Studies* 2001 (3): 10-11.

[4] Environmental Impact Assessment Training Resource Manual. *UNEP Documents* [On-line serial], *3*. Retrieved June 2002 from the website: http://www.unep.ch/etb/publications/EIAman/Intro Manual.pdf.

[5] Shu Min and Li Xikun. 2006. Analysis on Transboundary Environmental Impact Assessment of Transboundary Freshwater. *Journal of Kunming University of Science and Technology (Science and Technology Edition)* 2006 (31):432-438.

[6] Chainarong Sretthachau and Pianporn Deets. 2003. Downstream Impact of Hydropower and Development of an International River: A Case Study of Lancang-Mekong. *Papers for the United Nations Symposium on Hydropower and Sustainable Development* [On-line serial], *3*. Retrieved October 24th, 2004 from the World Wide Web: http://www.irn.org/basics/conferences/beijinghydro/pdf/searin.pdf.

[7] WCD Case Study: Pak Mun Dam Mekong River Basin Thailand Final Report in November 2000 [On-line serial], from the World Wide Web: http://www.centre-cired.fr/forum/IMG/pdf/F8_PakMunDam.pdf.

[8] Gráinne Ryder. 2004. Ten Reasons Why the World Bank Should Not Finance the Nam Theum 2 Power Company in Lao PDR. *Probe International Backgrounder*. 2004(6): 1-2.

[9] The United Nations Convention on Biological Diversity. 1992. Article 14 Impact Assessment and Minimizing Adverse Impacts [On-line serial], *3*. Retrieved October 12th, 2006 from the World Wide Web: http://www.cbd.int/convention/about.shtml.

[10] The United Nations Convention on the Law of the Sea. 1982. Article 12 Protection and Preservation of the Marine Environment [On-line serial], *3*. Retrieved October 12th, 2006 from the World Wide Web: http://www.lawofthesea.net/convention.htm.

[11] Angela Z. Cassar and Carl E. Bruch. 2004. Trans-boundary Environmental Impact Assessment in International Watercourse Management. *N.Y.U. Environmental Law Journal*. 2004 (10): 169-244.

[12] The North American Agreement on Environmental Cooperation. 1997. Article 10 (7): a-c [On-line serial], *3*. Retrieved October 12th, 2006 from the World Wide Web: www.worldtradelaw.net/nafta/naaec.pdf.

[13] The Espoo Convention on the Environmental Impact Assessment in a Transboundary Context. 1991. Article 1 (viii). [On-line serial], *3*. Retrieved October 12th, 2006 from the World Wide Web: http://www.unece.org/env/eia/eia.htm.

[14] Neil Craik. 2006. Deliberation and Legitimacy in Transnational Environmental Governance: The Case of Environmental Impact Assessment. *N.Y.U. International Law and Justice Working Papers* (Global Administrative Law Series). 2006 (10).

The Development and Application of CORS Technology and Its Value in the Solution for Environment Protect in the GMS

Shi Kun and Wang Yong*

Abstract— *Continuously Operating GPS Reference Stations often referred to by the acronym CORS. With the CORS constructing and applying in the world, it brought good benefits of social and economic. This paper will describe the development and application of the CORS. we will introduce the application of CORS in environment protect, environmental monitoring and assessment, geodesy, monitoring the safety of large structures, weather forecasting, Digital City, navigation, precision agriculture and other aspects. And an example of CORS in Yunnan province of China, which was setup three years ago, has been shown. Finally, this paper mentions the values, problems and the solutions of the CORS have been out in the practical application. At the same time we have described the outlook of application and development of the CORS combining the characteristics of the GMS, and discuss which role will the CORS play for the social and economic development of the GMS.*

Keywords— **CORS, Environment Protect, GMS, GPS.**

1. INTRODUCTION

With the mature development of CORS, it has been widely applied.

1.1 CORS application is mainly in the following aspects.

a) CORS can provide a new technical idea for large-scale control network of the country or region, and provide real-time dynamic framework for digital city.

b) In the investigation and exploration of resources, CORS can provide higher accuracy, stronger integrated application than conventional techniques. CORS combined with RS and GIS can provide the geochemical data for prospecting and basic geological study. At the same time, we can combination network RTK\RTD with PDA or other terminal equipment to higher efficiency survey in the regional of established the CORS.

c) In the deformation monitoring of the dam, bridges, high-rise buildings and other large structures, the application of CORS is widely and effectively. The CORS system is small CORS network that applied in the monitoring deformation. Its accuracy is mm (millimeter) precision for deformation monitoring. It can provide real-time dynamic analysis, including the frequency analysis etc. It has obvious advantage in the accuracy, frequency, timeliness, effectiveness and other aspects, when CORS system compared with the traditional deformation monitoring techniques.

d) For natural disaster monitoring, prediction and prevention, CORS can provide a framework or a fixed base for regional landslide monitoring. Therefore, we can timely, scientifically judge the affected region, and provide a scientific basis for decision-making of the prevention. At the same time it can reduces the cost of monitoring. So the real-time and reliability monitoring is come true.

e) About establishment of Digital City or Digital Region, CORS were able to meet urban planning, urban construction and environmental monitoring, research and many other requirements.

f) In weather forecasting, search and rescue and other fields, CORS technology has been widely applied, and made a good effect.

1.2 The development and application of CORS in some areas

a) US National Geodetic Survey CORS

The system is enhanced GPS system; all GPS stations can provide phase data and pseudo-code data by Internet in the country. And constitute a dynamic new generation of national reference system. Used mainly include measurements of mapping and GIS applications, but also for research and other services.

b) Canadian Active Control System (CACS)

CACS is established for Canadian National Geodetic dynamic Control network by The Geodetic Survey Division, and its purpose is to improved GPS capability, provide Spatial Reference System and to meet other need.

c) Other CORS System

Germany, Japan, Switzerland, Belgium, Korea, and other nations have also established the CORS systems.

d) CORS in China

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Seventeen cities have set up their own CORS system in China. There are some typical CORS systems of them, such as Jiangsu Province CORS, application of GPS network in Shanghai, Shenzhen CORS, and Kunming CORS, Sichuan earthquake GPS monitoring network, and Beijing integrated services CORS system. They are mainly for mapping, urban planning, urban management, traffic, security, environmental monitoring, and meteorology and so on.

All these show that CORS system been applied to the life of people around the world. It is play an important role in the development of social and economic. We believed that CORS would play an active role in the development of the GMS region.

2. THE PRINCIPLE AND THE SYSTEM CONSTITUTE OF CORS

This prater we will discuss the basic principle of CORS, three theoretical models, Centralized RTK, network RTK, single Station RTK, and working principle of subsystem and so on.

2.1 The principles of CORS

CORS is a network system that make use of the GNSS technology to establish a CORS system in city, region, and a country .It according to a certain distance ,and connecting each reference with the data centre make up a network ,by using of the computer, and the data transmission by the internet (LAN/WAN)technology. In addition, the data centre gathering data from the reference station, carries on processing using the reference station software, then automatically distribute the different type primary data and correction data to the different type, the different demand, the different level user, and other related GPS services.

2.2 The theoretical type of CORS

The theoretical type of CORS has approximately following three kinds.

The first kind based on VRS (Virtual Reference System) theory. It can compute the baseline of each GPS reference stations that near the Rover to estimate each error. Then the central control station will establishes a Virtual Reference System (VRS) according to the triangle interpolation method. At the same time the software of CORS will computer the correction data for Rover position, and send the virtual reference stands correction data to the Rover, the Rover combines with its own observation value real-time figure out the Rover's precise position finally.

The second kind is a completely net resolving model which proposed by GEO Corporation Dr. Gerhard Wuebenna, and it is a dynamic model.

It requests all Reference stations synchronized send no different correction observed value to the central control station; the observed value is real-time gathered. The real-time processing of the observed value through the central server, it will produces the spatial error correct parameter, it is called FKP, Then the central server send the FKP parameter to the Rover in the service areas by the form of RTCM information.

The third kind is the Main Station and Auxiliary stations technology. It is based on the latest multi-base stations, multi-system, multi-frequency (L1, L2, L5) and multi-signal no different processing algorithm.

It is essentially an optimization about flat plane correction parameter (FKP), choosing several local reference stations to figure out the correction parameter, and send the differential correction of Main Station and auxiliary to the Rover and correcting it, we can get the precise coordinates finally.

2.3 Centralized RTK (or Reverse RTK)

The RTK of Central server-based network is the same as the Centralized RTK or Reverse RTK. The positioning mode adds a real-time solution to the central servers at the core operator between the center of CORS and the Rover.

Further to the server installation and management of data in line with the main purpose of the application software and system integration. It can be in the flow of data between the center and the establishment of a multi-user ASP center (see Figure 1).

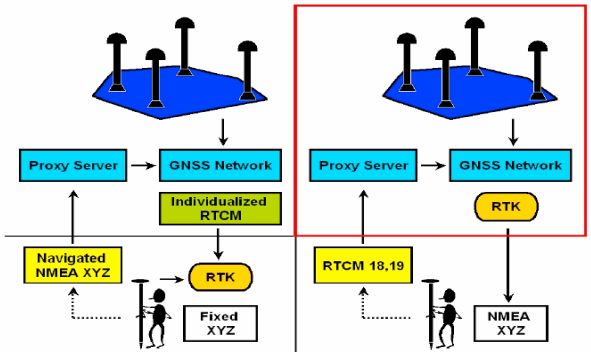

Fig. 1. Standard networ RTK(left), reverse RTK(right)

2.4 Positioning principal of Network RTK

RTK of GPS reference station system is network RTK. Network RTK is a new technology, which is developing based on conventional RTK and differential GPS. Conventional RTK established on the hypothesis that reference station error is correlative with rover error. When the rover is close to the reference station (e.g. less than 10 to 15 km), the result is good. However, with the interval is increasing between reference station and rover, the error correlation is getting worse. In order to obtain precise positioning results in this situation, a particular method is need, which is setting some reference stations equably, constituting a reference network in a large area.

Using for reference of basic principal and method of wide area differential GPS and local area differential GPS with some reference stations, performing RTK operation by using GPS reference station system's network solution model. Through observation model and simulating system error source related to distance, clearing or reducing the error influence, then obtaining the available and reliable positional results.

2.5 The component of GPS reference station

A CORS system (also known as a permanent reference stations or stations), includes a GPS receiver, a fixed antenna in a stable place and a reliable power supply.

Three or more of stations will buildup a CORS-net. The CORS buildup with GPS station subsystem, Communications Network Subsystem, Data center subsystem, Users subsystem, etc (see Figure 2).

The computer server software of CORS, it can control a lot of information from a single reference station or multi-stations.

Assuming the CORS is a single reference station, the computer will linked directly with the receiver.

If the CORS is a multi- station, the network servers usually on the control center, by telephone, LAN, WAN or Internet way connected with the GPS receiver.

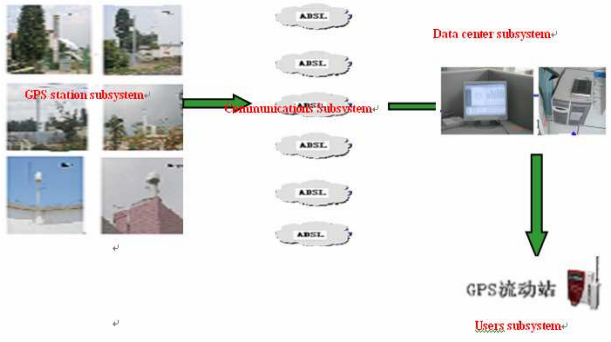

Fig. 2. Component of GPS reference station.

2.6 CORS technical specifications

The CORS not have the uniform standard at present all over the word. We should cover following several aspects from the application practice.

a) Effective range of service

b) Availability

c) Reliability

d) Accuracy

e) Efficiency

f) System average non-fault time, integration monitoring, fault-tolerant as well as system intellectualization, automation, information level.

3. THE BUILDING OF CORS AND THE ADVANTAGES IN APPLICATION

3.1 The key technologies of CORS

a) The Communication Technology of CORS

Construction of CORS communication network: CORS network is component of GPS data communication networks, the GPS Reference Stations will achieved the immediately uninterrupted communication about all data and control center; the way of communication have the fiber, ADSL and such as VPN(Virtual Private Network).

b) Distribute the correction data

Rover users can connect with the data center by the GSM/GPRS wireless technology. There is a GPS Reference Station System server in the data center. In addition, Rover can get the RTK corrections data form the data center then calculate the Rover's coordinates.

3.2 Problems and advantages of CORS

The advantages of CORS:

(1) The CORS can always upgrade and expansion. The new station can be added into the CORS system, that will increase the coverage area, and the software of CORS can always upgrade. Therefore, the CORS is Low prices. (2) CORS System is flexibility, security, reliability, stability. (3) The Network RTK compared with the traditional RTK. The accuracy of Network RTK is improved. In the coverage areas of CORS, the precision of coordinates always 1-2cm (centimeter), it has been limited by the distance of the stations not any more. (4) The reliability of CORS is improved. (5) The requirement for operation of CORS is reduce.

4. THE APPLICATION OF CORS IN DIFFERENT FIELDS

The application of CORS is following:

4.1 To build and maintain a high-quality baseline geocentric coordinates

When CORS is established, we can compute higher accuracy coordinates by use the Continuous Observed data.

4.2 Meet the needs of geophysical and environmental monitoring

The important application of CORS is to meet the needs of geophysical and environmental monitoring. Also, support the earthquake monitoring sectors such as mobile Internet service to the monitoring point for millimeter precision monitoring operations. For the monitoring and prevention of geological disasters is a major issue. In the support of CORS, the use of GPS technology can greatly improve the efficiency of operations and shorten the observation period. In addition, we can reduce construction costs, can do the trend analysis and comparison by the uniform precision data.

4.3 GPS Meteorology

GPS Meteorology is a new branch. It reformed within 10-20 years.

GPS radio signals through the ionosphere and Troposphere and produce the delay and Dispersion, using these phenomenon do Numerical Analysis. In particular, it will accurately extract the atmospheric water vapor content and distribution. Therefore, we make an accurate prediction about the time and intensity of rain. In addition, we will reduce the loss of lives and property that arose by disastrous weather.

4.4 Meet the needs of precision agriculture.

After the completion of CORS, Precision agriculture system has included in future development plans, backward farming techniques will disappear. At the same

time, under the management of the computer systems, we will really realize the modernization of agricultural production.

5. THE ENVIRONMENT OF GMS REGIONAL

5.1 GMS regional environmental generalization and features

Greater Mekong Sub region is China's Yunnan Province and Myanmar, Laos, Thailand, Cambodia, Vietnam 5, total area of 2.3319 million sq km, with a combined population of about 230 million. The region is rich in resources and beautiful scenery, rich cultural background, and carries tremendous potential for development.

The complicated geological structure of Greater Mekong -river valley, large population and low cultural qualities, particularly harsh conditions on the upper and middle reaches of the Lancang River, so ecological environment is fragile.

The Greater Mekong -river valley is Entire mountain valley to the main rivers cutting strong, a small proportion of land available for farming. More serious soil erosion, especially middle serious; Frequent natural disasters, Zhongdian - Dali and Simao - Laizhou.Tengchong - Gengma three seismic zone, an earthquake occurred, and easily leads to failure, natural disasters such as landslides and mud-rock flows.

River imbalance in the distribution of industrial production, mainly concentrated in downstream areas. Polluting industries are paper manufacturing, food processing, non-ferrous metal mining and smelting, building materials industry, the resources and raw material-type. However, industrial production scale is small, industry concentration and distribution of the total contamination is not serious.

5.2 GMS regional Environmental Protection Status

Since the 1990s, The Asian Development Bank positively promotes this regional countries cooperation in the field of environmental protection. As one of the seven priority areas of cooperation, it sets up a Working Group on Environment. In April 1994, the third regional ministerial conferences, with the participation of Cambodia, Chinese, Laos, Myanmar, Thailand, Vietnam six countries unanimously admit that. The conference has promulgated ‘Mekong River Regional Environment Minister united declaration’. All countries' minister and the representatives stressed in the manifesto that must strengthen this region environmental protection and the sustainable development, protects this area frail ecological environment and the biodiversity. Therefore, the environmental protection is a key domain of the Mekong River regional economic cooperation.

The main content of cooperation in environmental protection

(1) Prevention of natural disasters

The natural disasters is seriously and frequently in Mekong River valley, so the cooperation launches natural disaster research which including the earthquake, the landslide, the mud-rock flow and so on. These seriously harm people life and property security, so we must establishing the union man-machine forecast system, the disaster management, and the information exchange in order to reduce the regional natural disasters and protect people from the natural disasters.

(3) Establish the Great Mekong environmental monitoring and information system

The view of the entire Mekong Basin countries, the water environment contributions, the use of wastewater, and other basic conditions are not uniform standards for data and monitoring.

5.3 Example of Kunming city CORS

Kunming CORS in Yunnan province of China was setup three years ago in June2005.It was consisted of six reference stations and covers 6000 square km over Kunming city area. The structure of the system shown in figure 3.It can apply various position services, accuracy class from meters to centimeters for resource development, geological disaster monitoring, environment protection, city planning management etc departments. More details of application of Kunming CORS will be able to supply by authors of this paper.

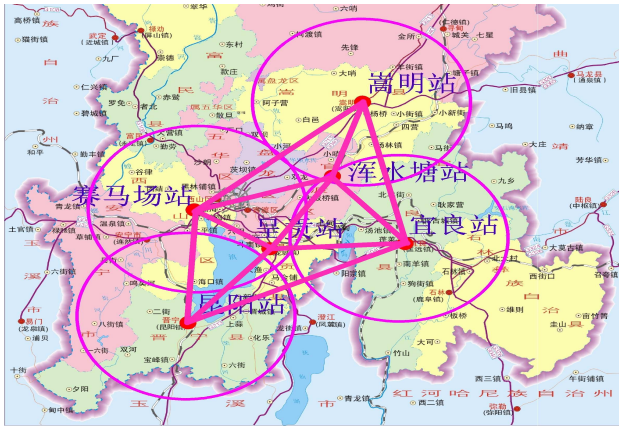

Fig. 3. The structure of Kunming city CORS.

6. SUMMARY AND CONCLUSION

CORS in the GMS region will play an important role in environmental protection and monitoring.

Based on the present situation of GMS region natural environment, CORS apply in mangy fields, such as investigation of the land and the protective forest, the research and forecast of natural disaster, earthquake, landslide, mud-rock flow. And the water volume and the subsoil water level monitor , the water body pollution monitor, the weather forecast, the route renovates, the navigation, large or middle hydroelectric power stations distortion monitor and so on many services.

The length of Lanchan River - Mekong River is 6th all over the world. It has 4880 kilometers, average discharge is 15,060 cubic meters pre seconds, average diameter current is 475 billion cubic meters, height difference is 5,060 meters, the water and the electricity storage capacity is 94.564 million kilowatts. According to the

GMS regional characteristic and the CORS own characteristic, should establish some small CORS systems, which passes through six countries. At the same time, we can choose certain stations or all stations of the six CORS systems to set up 'the Mekong River basin CORS system'.

It is a basic frame of the environmental protection and a monitor. We will do the same standard resource investigation, the geological environment investigation, the natural disaster forecast, and the electricity development and so on under this basic frame. In the initial period of establishment the 'Mekong River's basin CORS system', we can establish a small or the partially CORS system in the district of six countries which natural disaster is seriously and frequently.

Along with the economical development, we can gradually expand these partial CORS system to the entire Mekong River valley and establish the integrity CORS system, which has huge functions.

Along with the development of GMS regional economy, technology, the 'Mekong River valley CORS system' will become an integrated monitors system and the information system's platform of the GMS region. Simultaneously it will provide the real-time dynamic frame and the base platform with the comprehensive function for 'Digital GMS'. It will realize 'a platform, an investment, and many kinds of services'.

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REFERENCES

[1] Fangs, Y., & Rizzo, C. (2005), Three carrier approaches for future global, regional and local GNSS positioning services: Concepts and performance perspectives, 18th Int. Tech. Meeting of the Satellite Division of the U.S. Institute of Navigation, Long Beach, California, 13-16 September, 2277-2287.

[2] Anderson, J. M., and Mikhail, E. M. 1998. Surveying theory and practice, WCB/McGraw-Hill, New York.

[3] Ayers, H. B., and Bourdon, M. 1993. Evaluation of System-200 over long baselines measured on the Ottawa GPS basinet, Leica Canada, Ontario, Canada.

[4] Henning, W. E., Carlson, E. E., and Nikiski, D. B. 1998. ''Baltimore County, Maryland, NAVD 88 GPS-derived orthopedic height project.'' Survey. Land Inf. Serve., 58~2. 97–113.

[5] People, Great Mekong Subregion - GMS. [On-line serial], Retrieved April 04, 2006 from the website: http://world.people.com.cn/GB/8212/60991/60996/4270091.html

Pileated Gibbon (Hylobates Pileatus) in Samkos Wildlife Sanctuary. Do They Have a Future?

Vorn Vichheka

Abstract*— *Samkos is a Wildlife Sanctuary gazetted through Royal Decree which means strictly protected. It covers approximately 331.000ha of which approximately 235.000 ha is tall evergreen forest considered as Pileated Gibbon (Hylobates pileatus) habitat. The Pileated Gibbon is listed as "vulnerable" by the IUCN red list but the number of Pileated Gibbons is very high in Samkos Wildlife Sanctuary where the population is believed to number approximately 6100 individuals. However, human activities such as illegal hunting, habitat degradation and infrastructure development pose serious threats to the long term survival of the Pileated Gibbon. If these activities continue at the current level in the future it is believed that the population of Pileated Gibbon will decrease to critical low levels within the next 10-20 years.

***Keywords*— Habitat fragmentation, Infrastructure development, Pileated gibbon.**

1. INTRODUCTION

The Pileated Gibbon (*Hylobates pileatus*) is the most common of Cambodia's two gibbon species. It is listed as vulnerable on the IUCN red list whereas the yellow cheeked crested gibbon *(Nomascus gabriellae)* is listed as Data Deficient (Long & Swan ,2005).

Cambodia is considered a global stronghold for the Pileated Gibbon (Daltry, 2000). It is estimated that Thailand contains approximately 7500 groups of Pileated Gibbon (Tunhikorn *et al*, 1994) whereas Cambodia contains more than 30.000 individuals (Duckworth *et al*, 1999; Traeholt *et al*., 2005). Phnom Samkos Wildlife Sanctuary (PSWS) is part of the large block of forest in south-western Cambodia known as the Cardamom Mountains. It borders Central Cardamom Protected Area to the east and Southern Cardamom Mountains to the south. It covers approximately 331.000 ha of which about 235.000 ha is tall evergreen forest. It constitutes an important part of the Cardamom Mountain Ecoregion, an area spanning over 1 million hectares of relatively un-developed forest, wetland and mangrove habitat. PSWS takes its name from the mountain, "Samkos", which is the second highest (1717 meters) mountain in Cambodia. It is mostly covered in dipterocarp woodland and evergreen forest.

A large part of PSWS consists of ideal habitat for Pileated Gibbons as well as many other wildlife species. However, PSWS is also a target for illegal logging, agricultural encroachment and infrastructure development whereas wildlife is threatened by hunting, habitat loss and/or fragmentation (Traeholt, *et al*., 2005). Loss of Pileated Gibbon habitat in 2004 was 0.4%-4% in concession areas and between 7.2-98.3% in protected areas higher than in 1997, which lost only 1.7 % of evergreen and semi evergreen forest which is a typically preferred by gibbons(Coleridge *et al*., 2005)

According to UNDP (2004), 90 percent of Cambodia's population, approximately 13.1 million, live in rural areas and depend on natural resources to support their livelihoods. Hunting for meat or pets for the national and international trade has provided significant additional revenue to local communities and appears to be the largest threat to primates (Daltry & Momberg, 2000).Hunting can remove many individuals that are still reproductively active and subsequently result in a population decrease of a species (Daltry & Traeholt, 2003). Species, like Pileated Gibbons, with extended reproductive cycles are particularly vulnerable to hunting. Apart from local community encroachment for agricultural production many people chose to resettle in remote forested areas where land is either cheap or free (Daltry & Momberg, 2000).

Development, such as road construction (e.g. Phnom Penh to Koh Kong) across the Cardamom area and hydropower dams, are planned for the future (Paley & Hammond, 2002)

In this study, I used Pileated Gibbons in PSWS as an indicator of habitat "health". The aim of this study is to analyze the effect, if any, on the population of Pileated Gibbons in Phnom Samkos Wildlife Sanctuary and, based on various human activities, predict possible future population trends. Since Pileated Gibbons require relatively undisturbed forest habitat, the presence of Pileated Gibbons are also a reasonable indicator for possible population trends of other and more threatened species.

2. METHOD

This review is based on data retrieved from earlier publications and reports. In order to predict future population trends of Pileated Gibbons I set up three criteria as variables, which can directly and indirectly result in population change,

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1) Change in habitat: The amount of suitable gibbon habitat can increase or decrease for various reasons (agriculture, logging, replanting and protection). The trends in habitat loss, or gain, were measured by analyzing forest cover between 2000 and 2006.

2) Hunting: It is not possible to measure the exact number of hunters and/or hunted Pileated Gibbons in PSWS. Instead, I used the data in 2004 -2006 trends in hunting activity based on a) number of confiscated individuals, b) number of apprehensions, c) number of court cases/convictions, d) number of protection rangers, and e) the scale of wildlife trade in general. By comparing these components from two, or more, different time periods it is possible to get a relative indication of possible future scenarios in hunting activity.

3) Infrastructure development: Large development projects, such as construction of highways, hydropower dams, and urban areas often results in severe habitat loss and/or fragmentation. I measured the possible impact on PSWS from infrastructure projects with number of roads, hydropower dams, and resettlement schemes. The additional effect associated with, for example, roads is often increased accessibility to, previously, remote areas, which often results in increased illegal hunting, logging and mining activities too. A review of the planned infrastructure projects will provide a good indication of how PSWS will appear in geophysical perspective in the future.

I used the population density of Pileated Gibbons in PSWS estimated by Traeholt *et al.* (2005), who also undertook a population simulation exercise of the species in PSWS (Traeholt *et al.*, 2005). They predicted that Pileated Gibbons are in risk of declining to critically low number in 40-50 years. However, this simulation was based on habitat loss/gain trends from 1997-2002 and because the simulation programme used for this prediction (VORTEX) considers habitat loss linearly, it may result in a different prediction should the rate of habitat loss decrease non-linearly post 2002. By adding, additional information falling under the three criteria, it is possible to elaborate even more on the future population trends of Pileated Gibbons in PSWS.

3. RESULT

Pileated Gibbon in Samkos

Recently, Pileated Gibbon population densities were estimated to number approximately 3,102 groups (6,100 individuals). The survey showed a heavy bias toward single males (Traeholt *et al.*, 2005). One of the sites in PSWS recorded seven single males out of eight groups and three out of nine recordings were single males in the second site. Based on the habitat data from 1998-2005 and with the moratorium on logging activities from 2000, it is likely that the habitat scenario in Samkos appears slightly different today.

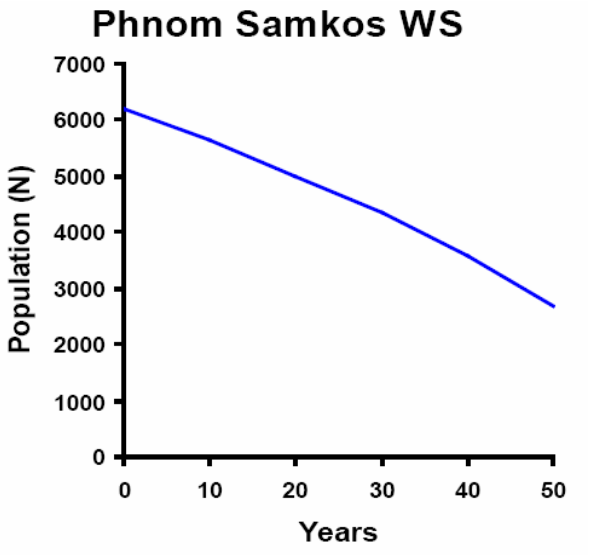

Fig. 1. *H.pileatus* population trend (blue line) inPhnom Samkos WS using VORTEX input to predict its trend. Source: (Traholt *et al*,2005)

1. Hunting

Hunting is an enormous threat to survival of animals within the forest in the lower Cardamom Mountains. This activity is usually done by rural people for food, medicine and wildlife trade. Snares and guns are used to hunt large mammals and fast escaping mammals. Indeed, at O RATKRAH market, Samlaut District, wild animal products and meat were sold daily (Paley & Hammond, 2002). Wildlife populations are likely therefore to be under considerable threat and some species may have been reduced to population levels that are no longer viable. It is not just local people who pose a threat to the wildlife and forests. As a remnant of the civil war combined with PSWS's position on the border with Thailand, there are significant numbers of Cambodian Army troops stationed in Samlaut District, including some inside the protected areas. However, the level of hunting of Pileated Gibbons appears to be low since its meat is not popular and they are fast, usually escaping from pursuing hunters but raising them as a pet is more common. Pileated gibbons are primarily collected from the forest to sell as pets. A baby gibbon costs $120 and $59 for adult females. One study found that some people in PSWS kept at least 3 gibbons as pets (Bansak *et al*, 2000). These have probably been collected by the hunters after they killed the mother. Because reproduction in female gibbons starts at 8 years with an average of 1 progeny per year, killing female gibbons is a serious ecological problem, because it removes the baby as well as a reproductive individual. Meanwhile, as access to wildlife sanctuary improves and collectors switch from other species whose populations are becoming depleted, threats to gibbons will increase within Southeast Asia (FFI, 2001). The number of resident hunters appears to have decreased slightly (table 1) while the number of rangers have increased from 5 rangers in 2000 to 48 rangers in 2006. The collaboration

between Non Government Organization (NGO) and the Ministry of Environment (MoE) and Ministry of Agriculture, Forestry and Fisheries (MAFF) resulted in improved prevention of illegal activities and subsequently protection of wild animals in PSWS. However, the number of traps confiscated in 2006 was higher than in 2004 and 2005. In May, 2004 to March 2005, the number of traps seized reached 336 whereas the number of traps seized was 1317 in 2006 (FFI & MoE, 2005, 2006). This suggests that either hunting activities have increased or ranger patrols have become more frequent and efficient. Furthermore, the number of dead wildlife recorded in 2004-2005 was six, which increased to 17 in 2006. Most of the wild animals were Bear claw, Sambar, Monitor lizard, monkey and Pangolin (FFI & MoE, 2005).

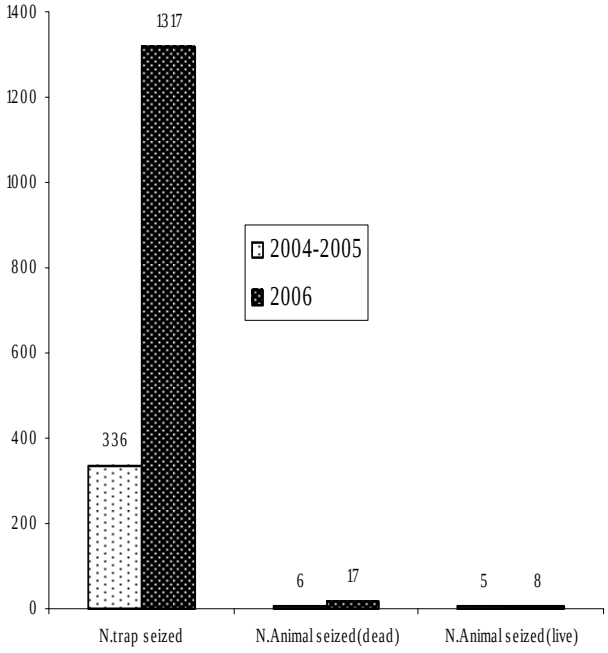

Fig. 2. Different years of trap confiscation (May, 2004 to Mach, 2005 and 2006(1-11). Source: *(FFI & MoE, 2005)*

2. Habitat loss and fragmentation

A part from the mountain areas at Phnom Samkos and Phnom Aural, the habitat type in PSWS is not significantly different from the rest of Cardamom mountains, with a major vegetation type occurring across this ecoregion being dominated by dipercocarp forest that covers the low lying basic area and attitudinally zoned evergreen forest on the mounting slope and peak (Daltry, 2000).In 2000, a survey in PSWS showed that the density of evergreen forest cover was approximately 876 individuals per hectare and dry deciduous forest cover approximately 720 individuals per hectare. The abundance of the forest surrounding Cardamom Mountains has been exploited by opposing political factions in Cambodia that used timber to finance campaigns/ The logging activities have had significant social and ecological consequence for local communities and wildlife. In 1999, logging activities were much more tightly controlled, 20-30 sawmills were shut down and the trade was ceased, however, local powerful sectors continued to organize illegal operations, often facilitated by the police and the army (Global Witness, 2002). In 2000, illegal logging occurred in both PSWS and Phnom Aural (PA) wildlife sanctuaries and in logging concessions in Thmar Bang District as well as along the Thai border (Alonson *et al*, 2002). In 2002, two large areas in PSWS were given to companies as logging/agricultural concessions by local authorities. The District Governor denied knowledge of one of them (Pheapimex company) and claimed the other was inactive (Youri Sako company). However, in other parts of Cambodia logging companies have shown little compunction in logging illegally within protected areas, and are still actively in violation of a government moratorium (Paley & Hammod, 2002). In November 2001 Global Witness exposed illegal logging and that the export of timber to Thailand took place (Global Witness, 2002). At that time, 19 Thai loggers were incarcerated for six month after that they were released (Global Witness, 2002). Since 2004, 65 forest crimes were record by rangers of which more than 25% were soldiers in PSWS (Claridge *et al*, 2005). Locations of military development zones have yet to be disclosed, and the development of these areas is often associated with logging operations and violence against local communities (Paley & Hammod, 2002).

Table 1. Decreasing of violator from 2004 to 2006. The PA resident appears to decrease from 2004-2006. Source: (FFI&MoE,2005)

Type of violators (include Forest crime and illegal hunters)	2004-2005 (May to March)	2006 (Jan-Novem)
Army	39	1
Police	13	0
Military Police	39	0
PA resident	90	25
outsider	1	44
Local Authority	0	1
Commercial company	2	2
other(CMAC)	0	1
Total	184	74

World Bank estimated forest in the Cardamom Mountains would be commercially logged out by 2003.Illegal forest activities appeared to decrease dramatically after forest concessions were banned by Prime Minister Hun Sen combined with an increased presence of rangers. In 2006 (from January to November) Forest Crime decreased compared to 2004 and 2005 (Figure 3). Only 84 cases were reported, of

which 26 cases were illegal NTFP factories (Mreah Prove Factories), 5 cases were brought to court, 35 cases were non re-offence contracts signed, 9 cases were information sign posted and 9 cases were successful prosecution (FFI & MoE, 2006).

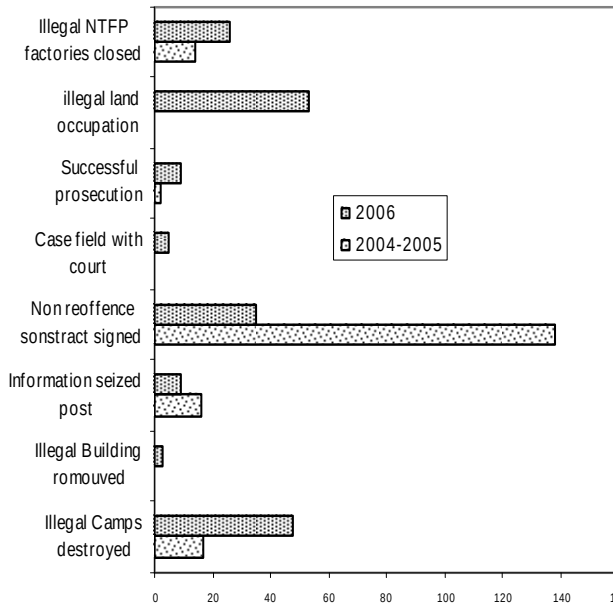

Fig. 3. Number of forest crime and land encroachment in 2004-2005 and 2006. Source: (FFI & MoE, 2005)

However, Land encroachment for agriculture and settlement increased from 2004 to 2006.The amount of illegal land clearing is 1 plot in 2004 compared to 53 plots in 2006, which corresponds to approximately 316.04 ha (FFI, 2006).

Fragmentation of forests in PSWS has occurred, as a result of agricultural land, logging areas, settlement, and road construction which depleted biodiversity (FFI, 2000). Migration is increasing from day to day, disturbing wildlife habitat (Daltry, 2002). Human populations in Veal Veng District located in Samkos mountain are increasing every year (FFI & MoE, 2005). Lutheran World Federation (LWF) supported by the United Nation's High Commission for refugee's (UNHRC) and World Food Program (WFP) developed infrastructure such as roads, health centers, wells and schools as well as systems for agricultural extension. In 1999 the total population in Veal Veng District was approximately 39 families (Bansak *et al*, 2000)During 2000, the population doubled to 5025 people as emigrant families returned to the area. In 2005 the population has increased to 10516 people in PSWS (FFI & MoE, 2005).

3. Infrastructure development

Road construction and the development of hydropower dams can also lead to habitat loss and/or degradation. Although building roads in Wildlife Sanctuaries is not strictly illegal it can result in negative impact on wildlife, because of habitat fragmentation and possible disturbance of sensitive habitat. The primary concern is that building roads can divide an area into two parts and, in some cases, reduce its conservation value. So far, one main road has been constructed spanning approximately 200km. A new road was constructed crossing the mountain range and opening up the area for the first time. One road was constructed by GATT international logging company through the middle of the Cardamom mountain range from Koh Kong to Pursat via Thmar Bang (located in Samkos mountain), but it was banned by the department of forestry in 2001. In addition, You Risar Kor Company was extending the road from its concession north of Samkos mounting to Koh Kong via OSom. The other two major roads were constructed in 2003 linking Koh Kong directly with Phnom Penh. In addition, 50km of the road has been constructed for national security reasons in the part of PSWS adjoining the Thai border in the north of Thmar Da village (Table 2).Currently, three hydroelectricity plans are under consideration in Samlaut District (Paley & Hammond, 2002).

Table 2. A number of road developments in the different places adjacent to and within PSWS. Source: (FFI & MoE, 2005)

Number of roads development	Location
1	Cross mount range
1	Cross PSWS
1	Middle of Cardamom mountain
1	North of PSWS
2	Linking Koh Kong with Phnom Penh
50km	Part of mount samkos

4. DISCUSSION AND CONCLUSION

The results presented in this paper indicate that if hunting, habitat loss and infrastructure development continue, the Pileated Gibbon and/or other wildlife species are likely to suffer population disturbance and possible decrease within the immediate future.

Forest disturbance is a major reason for population decline of many wildlife species. Species, such as gibbons that depend on tall evergreen forest as food sources are particularly affected by forest disturbance and clearing. Previous logging activities often disregarded sanctuary boundaries since law enforcement was limited and inefficient. During the civil war, parts of the forest were clear cut in some parts of PSWS, which is extremely detrimental to the forest because its ability to regenerate from clear felling is limited and requires long time to recover. Even though illegal logging activities were common in 1999 pristine forest remained in large tracts of Cardamom Mountains and PSWS.

Logging seldom takes place as isolated activities. Workers hunt for food as well as opportunistically

collect and capture tradable plants and wildlife species in order to supply their meager salary with additional income. and much of the Pileated gibbon were hunted for both food and for the pet trade, which is likely to have resulted in a population decline over the past decade. Since adult gibbons are unsuitable as pets females are often killed and eaten, while infants were taken and sold as pets. Such practice results in a double blow to the gibbon population, because it effectively removes more than two individuals from the population. This may explain the skewed gibbon sex ratio recorded by the FFI-primate team during surveys in 2004 (Traeholt et al., 2005).

Although the number of forest crimes have decreased significantly from 2004-2006 the number of trap confiscation has increased. This indicates that whereas the number of illegal hunters may have decreased the hunting pressure has increased, or, the enforcement patrols have become better and more efficient in detecting, discovering and confiscating traps. There is evidence that local settlers have stopped illegal hunting activities, probably because they wish to remain in the area and therefore tend to adhere to whatever law that is implemented as long as it makes common sense, and there is a chance that they will benefit from not breaking it. However, outsiders are still involved with illegal activities and a major part of illegal activities is associated with outsiders. The primary problem caused by local people appears to be related to shifting cultivation practices. Whereas slash and burn practices may stimulate crop growth and, eventually, increase the yield of a field, such fires are rarely monitored by the farmers who started them, and much less controlled. The result is that many of these fires spread as wildfires to surrounding tall evergreen forest with extremely detrimental consequences. For gibbons the burning of prime habitat obviously has very negative consequences, because their primary food sanctuary disappears into smoke. Resident gibbons may not have the opportunity to flee into neighboring areas, because these are often occupied with a dominant pair. If the habitat is not burned, gibbons may be disturbed by the heat and smokes generated by a fire and avoid settling in areas close to human settlement, even if some areas are ideal habitat for them

One of the most critical development aspects of PSWS is the considerable infrastructure development that has taken place during the past 5-8 years. The development of several roads has resulted in habitat fragmentation and since gibbons are reluctant to descend to and walk on the ground roads can form a formidable barrier to gibbons. Fortunately, pileated gibbons have been observed to cross roads on several occasions and as such roads are not necessarily a serious obstruction to gibbon distribution. However, roads create easy access for illegal loggers, hunters and settlers and this is probably the most serious negative impact of road construction. Even if local communities refrain from undertaking illegal activities, outsiders have easier access to remote ranges of PSWS and can rapidly extract wood, trophies and the other goods.

Another infrastructure development that has serious impact on biodiversity conservation in PSWS is the development of hydropower dams, because it will inundate large areas of the sanctuary. In addition building a hydropower dam will require additional road construction, particularly during the construction phase, which often encourages more settlers to enter the area. The impact of three proposed hydropower dams in PSWS may result in negative impact on pileated gibbons unless such side effects (increased settlers, illegal logging, hunting) are controlled properly. Whereas hydropower dams may also affect several species by inundating important habitats, it is uncertain to what extent inundation can impact gibbons, because it depends on the size of the inundation area.

In Cambodia most people are often extremely poor and lack income opportunities in urban areas. Therefore, many people tend to migrate to protected areas, including PSWS, to find fertile farmland, which in many cases end up being free of charge. The immigration of people into PSWS is still increasing (Daltry, 2003), and there is a risk that the use of natural resources in and around current settlements will become unsustainable if alternative options are not found. the birth rate in Cardamom Mountains is 2.7% (Daltry, 2003) and the increasing human population is likely to increase the pressure on land in PSWS. In spite of the positive initiatives taken to station ranger patrols and enforce the forestry laws, the escalating pressure on pristine habitats from infrastructure projects, new settlers and outside traders is likely to condemn much more habitat and many more gibbons to oblivion in the nearby future. It is uncertain, however, if gibbons will continue to thrive in PSWS in general, but considering the vast size of PSWS, there is a good chance pileated gibbons will continue to exist in the area, although in much smaller numbers.

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REFERENCES

[1] Alonso, L., Bunhlmann, K., Pilgrim, J., Sanderson, J., Muchoney, D. and Piece, A. 2002. Mini RAP Assessment of Silver Road logging Concession. Cardamom Mountain area, Cambodia Conservation International , Phnom Penh.

[2] Ashwell, D. 1997. Anaturiat Biodiversity Prospectus: A contribution forward the implementation of the conservation on biodiversity with particular emphasize upon Cambodia's terrestrial ecosystem. IUCN, Cambodia. Phnom Penh.

[3] Bansak, R., Eang Hurt, K., Piseth, H. and Kunthea M. 2000. Vegetation survey in PSWS.Cambodia. Primate Team office.

[4] Baltzer, M, Dao. N. T., Shore, B., James Hardcastle, J, Long, B, Clay, K. and Springer, J. 2001. The forest of the lower Mekong Ecoreegion Complex. Printing Enterprise N01 Cartography Publishing house, Hanoi.

[5] Bezuijen, M. R. 1993. Observation on the trade of Wildlife products in the medicine shop of street 166. Phnom Penh. Cambodia. Unpublished report to IUCN Cambodia, Phnom Penh

[6] Brockelman, W. Y. 1975. Gibbon Populations and their Conservation in Thailand. *Natural History Bulletin of the Siam Society* **26:** 133-157.

[7] Brockelman, W. Y and Ali, R. 1987. Method in Surveying and sampling forest Primate Population in tropical Rainforest. New York, pp. 23-62.

[8] Cardamom Mountain Wildlife Sanctuaries Project. Annual repor*t* May 2004 to May 2005, June. Cambodia, Cardamom Mountain project.

[9] Conservation International Organization (CI), 2002. Cambodia's Central Cardamom Protected Forest. International Media Outreach, Phnom Penh .Cambodia.

[10] Claride, G., Leth, V., and Chhoan, I. V. 2005. The effectiveness of Law enforcement Against and Wildlife Crime. Cambodia, Phnom Penh.

[11] Daltry, J. C. 2002. Social and Ecological Survey in Veal Veng District, Cardamom Mountains, Cambodia. Cambodia Program: Fauna and Flora International, Camobodia.

[12] Daltry, J. C. 2006. Sites Description: Phnom Sankos Wildlife Sanctuaries. Cambodia, FFI Printing [Unpublished].

[13] Daltry, J. C. And Momberg, F. 2000. Cardamom Mountain Biodiversity Survey 2000. Cambridge, FFI, Great Eastern house, Tenison Road, Cambridge.

[14] Daltry, J. C and Traeholt, C. 2003. Biodiversity Assessment of the southern Cardamom and Botum Sarkor Peninsula. Wild Aid: Cambodia Program and the Department of Forestry and Wildlife, Phnom Penh.

[15] Daltry, J. C. and Traeholt, C. 2003. Biodiversity assessment of the southern Cardamom and Botum Sakor peninsula. WILDAID, Cambodia Program, Cambodia.

[16] Defler, T. R., Vicente, J., Rodriguez, M., Jorge, I., and Comacho, H. 2003. Conservation Priorities for Colombian Primates. Primate Conservation (19) 10-18.

[17] Duckworth, J. W., Salter, R. E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999. Status Report, IUCN, Vientiane.

[18] Fauna and Flora and Ministry of Environment, 2005. Integrated Biodiversity Conservation and Development of Cardamom Mountains. Phnom Penh, Cambodia: Fauna & Flora international Cardamom Mountain Wildlife Sanctuaries Project.

[19] Fauna and Flora International, 2004. Selected Reading for Natural History Working Group, Gibbon PHVA. Phnom Penh, FFI Primate Team.

[20] Fauna and Flora & Ministry of Environment, 2004. Cardamom Mountain wildlife Sanctuaries project. Cambodia, Camobodia: MoE-FFI Cardamom Mountain Wildlife Sanctuaries Project.

[21] Fauna and Flora International & Ministry of Environment, 2002. Social and Ecological Survey of Phnom Aural Wildlife Sanctuary, Cardamom Mountain. Cambodia, Fauna and Flora International: Cambodia Program.

[22] Flora and Fauna International & Ministry of Environemnt, 2005. Cardamom Mountains Wildlife Sanctuaries. Cambodia, FFI Printing.

[23] Flora and Fauna International & Ministry of Environemnt, 2005. Cardamom Mountain Wildlife Sanctuaries Project. Annual report, Cambodia, FFI Printing [Unpublished].

[24] Flora and Fauna International & Ministry of Environemnt, 2005. Cardamom Mountain Wildlife Sanctuaries Project: Annual report May 2004 to June 2005. Cambodia, FFI Printing.

[25] Gippoliti, S and Omo, G. D. Primates of Guinea Bissau, West Africa Distribution and Conservation Status. Primate Conservation 2006: 73-77.

[26] Global Withness, 2002. Unlimited forest destruction. London, Global Withness Ltd.

[27] Kimhout, S., Bunnat, P., Poole, C. M., Tord, A. W., Davidson, P. and Delattre, E. 2003. Directory of important Bird Areas in Cambodia: Key Sites for Conservation, Phnom Penh. Wildlife Conservation Society Cambodia Program.

[28] Kimberley, A., Phillip, K. A and Abercrombie, C. L. 2000. Distribution and Conservation Status of Primates of Trinidad. Primate Conservation 2003(19) 19-22.

[29] Long, B. & Swan, S. R. 2000. Surveys in the Cardamom Mountains and Northeast Mondulkiri Province. Cambodia, Fauna & Flora International: Indochina Programme, Hanoi.

[30] Matin, M. A. 1973. Notes on the vegetation of Cardamom Mountains. Cambodia, Garden Bulletin 26: 213-222.

[31] Meijoard, E., Sheil, D., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskauda, D., Sethy, T. A., Lammertink, A., Rachmatika, J., Won, A., Soehartono, T., Stanley, S., and O'Brien, T. 2005. Life After logging. Jakarita, Indonesia Printer.

[32] Momberg, F. and Weiler, H. 1999. Conservation Status of Cardamom Mountain in Souwestern Cambodia: Preliminary studies. Fauna and Flora international : Indochina Program, Hanoi.

[33] Parr, W. K. 2003. Large Mammal of Thailand. Thailand, Saradadee Press.

[34] Paterson, J. D. 2001. Primate behaviors. America, United States of America.

[35] Paley, R. and Hammond, B. 2002. Cambodia Vision in Development. Phnom Penh, Cambodia.
[36] Richard, A. F. 1998. Primate in Nature. New York, W. H. Freeman Company.
[37] Schwann, T., Warren, B., Ronald, T., Usum, N., Parntep, R., Robert, C., Andraw, T., Kathey, C. and Ulusses, S. Population and habitat Viability analysis Report for Thai Gibbon: Hylobates Lar and H.Pileatus. Thailand, IUCN Conservation Breeding Group.
[38] Stericher, T. N. U. 2004. Conservation of Primate in Vietnam, Vietnam, Haki Publishing.
[39] The Cardamom Conservation Program and Conservation International, 2002. Phnom Penh, The Cardamom Conservation Program.
[40] Traeholt, C., Bunthoeun, R., Rawson, B., Samuth, M., Virak, C. and Wuthy, .S. 2005. Hylobates pileatus and Yellow checked crested gibbon, Nomascus gabriellae in Cambodia. Phnom Penh, Cambodia: FFI Cambodia programmed office.
[41] Tunhikorn, S., Brockelman, W. Y., Tilson, R. L., Nimmanheminda, U., Ratanakorn, P., Cook, R., Teare, A., Castle, K., and Seal, U. 1994. Population and Habitat Viability Analysis. Report for Thai Gibbons: Hylobates lar and H. pileatus. IUCN/SSC Conservation Breeding Specialist Group.
[42] University of Melbourine, 2005. Beyond EP: Living in Protected area, Community forestry in PSWS in Cambodia, Australia.

Key Impediments to Biodiversity Conservation in the Greater Mekong Subregion: Human Context

Shu Min* and Li Xikun

Abstract— *The conservation of global and regional biodiversity increasingly relies on the network of international cooperative protected areas. In this article we examine human demographics, land cover and land use, and agricultural suitability as main human context impediments that may influence the smooth work of biodiversity conservation in the GMS area. Moreover, through comparison, contrast, explanation, and argumentation, this thesis analyzes the ethical and economic problems and contradictions that may occur in the process of realizing biodiversity conservation and sustainable development in the subregion, and the article also provides clews for future protecting and research work performance.*

Keywords— biodiversity conservation, human context, impediments, sustainable development

1. INTRODUCTION: HUMAN DEVELOPMENT AND BIODIVERSITY CONSERVATION

The Millennium Ecosystem Assessment (2005) identified continued biodiversity loss as an important aspect to the decline of key ecosystem services that humans and other species rely upon. It is estimated that people may have increased the rate of global extinctions by as much as 1,000 times the natural rate typical of Earth's long-term history. Some 12% of birds, 25% of mammals, and at least 32% of amphibians are threatened with extinction over the next century [1]. Human activities have taken the planet to the edge of a massive wave of species extinctions, which further threatening our own safeties.

Human-induced habitats loss and fragmentations have been regarded as major threats to biodiversity conservation. By the end of the 20th century, human beings have used about 40% of the earth's territory and had changed one-third of the land area to urban using and agricultural fields [2]. Cultivating forests and wetlands into croplands, using rivers to generate power, and hunting wild animals for various benefits may not end all kinds of natural processes, but it will change our landscapes and disarrange all the natural processes.

Modern conservation of global and regional biodiversity increasingly relies on the network of international and regional cooperative protected areas. In the year of 2005, the Greater Mekong Subregion countries China, Lao PDR, Myanmar, Cambodia, Thailand, and Vietnam have promoted the plan of the Greater Mekong Subregion Biodiversity Conservation Corridors (GMS BCC) together. According to the plan, all the six GMS countries will cooperate with each other in doing scientific expeditions and assessments, building natural resources networks, and protecting rare species to realize biodiversity conservation and sustainable development in the Greater Mekong Subregion.

In this plan, the first proposed ten years GMS Biodiversity Conservation Corridor Initiative (GMS BCI) is to support the broad-based agenda of sustainable development identified by the GMS countries. According to the agenda, the GMS BCI will undertake activities in five pilot sites Xishuangbanna, Ngoc Linh – Xe Sap, Xe Pian, Dong Hua Sao, Dong Ampham, Tenasserim: Western Forest, Kaeng Krachan, and Cardamom Mountains [3] in the priority areas of GMS to conserve habitats for wildlife, to enhance ecological services, such as water supply and flood protection, and to improve local community welfare through poverty alleviation measures and sustainable use of natural resources. By the year of 2015, the GMS countries will have established basic biodiversity conservation landscapes and corridors for protecting and maintaining ecosystems, realizing sustainable and rational use of shared natural resources, and improving the livelihoods of people in the subregion. Therefore, this article further examines main human context impediments, such as human demographics, land cover, and agricultural suitability, so as to provide clews for future protecting and research work performance in biodiversity conservation in the subregion.

2. ASSESSING FEASIBILITY OF BIODIVERSITY CONSERVATION IN HUMAN CONTEXT

Human Demographics

Calculating human population in the Greater Mekong Subregion shows how many people in this area would direct affect and provide potential threat to the new Biodiversity Conservation Corridors. With a total area of 2.33 million sq. km, the Greater Mekong Subregion has a population of 246 million by the year of 2000 [4]. Over the past 30 years, the population of the Lower Mekong Basin has doubled. It is estimated that by 2025 the population in this area will increase another 30% to 50%.

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Although at the beginning of this article we mentioned that human activities, which may influence the earth environment directly or indirectly through various ways, is one of the ultimate reasons for biodiversity loss, and human activities reflect more accurately the adverse impacts towards environment, researchers and experts consider the population size of human settlements nearby or within wildlife habitats or core zones of reserves as the most potent source of threats to biodiversity conservation [5]. Human settlements may cause damage of forests, loss of habitats, increase in livestock densities, rapid development of commercial agriculture, and systematic and large-scale construction of urbanization.

In Yunnan Province of China, Lancang-Mekong River has a drainage area of about 88,700 sq. km where the population density is of 69.6 people per sq. km [6]. In other GMS countries, by 2004, Lao PDR has a population density of 24 people per sq. km, Myanmar has a population density of 74 people per sq. km, and Thailand has the density number of 124 people per sq. km. This number in Cambodia is 72 people per sq. km, and the population distribution in Vietnam is 246 people per sq. km which is the highest country population density in the whole world [7].

Although there is great variability in population densities associated with different areas in different countries of the subregion, research shows that once the distribution of population reaches to 10 or more people per sq. km, the adverse impacts toward the environment and biodiversity conservation occur [8]. Moreover, satellite images provide that even in the areas of some of the new conservation reserves in the subregion, population densities are high as well. Take the Lao PDR which has the lowest population density in the subregion for example, across the GMS BCI pilot site Xe Pian – Dong Hua Sao – Dong Amphan, within the Xe Pian National Biodiversity Conservation Area in the Lao PDR, the population is estimated at 50,000. Fourteen of the 80 villages in the 3 districts covered by Xe Pian are located inside the national biodiversity conservation area, and seven ethnic groups reside in and around the area. The total population of Dong Houa Sao is 28,800 and of the 82 villages contained in the 3 districts that it covers, two are inside the national biodiversity conservation area, and other seven ethnic groups reside within its boundary [9]. In addition, according to the demographic census, in some coastal and lowland zones in the subregion, the population density reaches to more than 750 people per sq. km [10].

In the Northern Annamites Rain Forests across the border between Lao PDR and Vietnam, in the Northern Plains Dry Forest areas in north Cambodia, in Xishuangbanna of southwest China, and in other vast tract of protected reserves, human settlements and population densities are considered to be significant threat to biodiversity conservation.

Land Cover

Land cover in the Greater Mekong Subregion indicates the capacity of biodiversity conservation in the newly established corridors. In the past years, land cover conditions in the Subregion has been changed by deforestation, agricultural cultivation, dams construction, urbanization, hydrologic response, water quality, topsoil erosion, biogeochemical cycles, land surface atmosphere interactions, and climate change.

With very few forested areas remaining; lowlands of the subregion are clearly dominated by rice paddies and croplands. Among these areas, the relationship between land cover and human settlements is clearly reflected in the central and northeastern agricultural area of Thailand, the Tonle Sap Lake and Inundation Zone of Cambodia, and the southern areas of Vietnam. In contrast, portions of mountain areas such as the Cardamom Mountains in Cambodia, parts of Xishuangbanna in China, and forest areas in Lao PDR are covered by fragmented forests and mixed agro-forestry landscapes.

Research on land-use change in Thailand in 1998 reveals conversion of forest, logging of natural forest, and farming in the forest areas are three major components of deforestation and land use transformation in this country. In 1960, 54% of lands at national level were covered by natural forest, 20% areas were covered by farmland, and 26% national lands are used for non-forest land development. However, in the year of 1998, new collected data shows that forest cover at national level in Thailand reduced to only 25.3%, simultaneously, farmland cover increased to 41.5% and other non-forest land-use took 33.2% of national land. Three major aspects of overall land-use change since 1960 in Thailand are: changes in proportions of land under forest, agriculture, and other uses; levels of each type of area per capita as the population has grown; and the proportion of the population officially located in metropolitan areas [11]. Resorts and golf courses convert land directly from forests and habitats. Urbanization, industry, housing, agriculture, and other constructions are rapidly devouring landscapes of natural biodiversity.

Agricultural suitability and agricultural economy

As a globally leading cause of habitat conversion, agriculture remains an enormous threat to conservation, a threat which is expected to increase markedly with anticipated growth in demand for food in coming decades [12]. As the Greater Mekong Subregion has such a huge population, among which the majority are smallholder and poor farmer population who live in rural areas where they lead subsistence or semi-subsistence agricultural lifestyles, agricultural suitability is a non-negligible factor when assessing feasibility of biodiversity conservation in this area.

There are two types of agriculture: subsistence and commercial. In most of the GMS countries, rice and other subsistence food crops have continued to be the mainstay and principal commodity of the economy. People grow crops both through sedentary agricultural practices and shifting-cultivation methods. Although research shows that growing crops in most mountainous reserves and gap locations would most likely fail to meet high human food demands and lead to subsequent agricultural expansion in order to generate desirable yields, and thus could result in the further loss of species

[13], in many poor areas in the subregion, subsistence farmers still commonly use the slash and burn or swidden agricultural method by which a portion of land is cleared and burned to provide at least one and up to three years of good crops grown. Once the land can no longer be utilized, a new patch of ground is slashed and burnt for another round of crops. This shifting-cultivation method has been considered to be one of the major causes of deforestation.

Another problem left over by history has been the illegal commercial cultivation of the opium poppy. Although the general trend of opium poppy cultivation is toward a decrease, today it is still grown and processed in the uplands of Myanmar and Lao PDR, and in some small pockets of Northern Thailand. This problem not only causes a series of other social problems but also provides potential threats to the biodiversity conservation because most of the growers have chosen deep mountains and remote areas nearby or within the natural habitats and reserves to plant the opium poppy, and governments' programs to curb production have had limited success because of the profitability of opium production and the inaccessibility of growing areas.

Broadly speaking, other widely applied practices relating closely to agricultural economy in the subregion include animal husbandry, fishery, agroforestry, and economic forest regeneration. Widespread conversion of the habitats into croplands and food supply cultivation areas and regenerating of natural growth forests for economic forests such as rubber plants, eucalypts, palm trees, tea gardens, and fruit trees, is an outstanding threat towards regional biodiversity conservation. Natural forests which are regarded as one of the most important elements for ecosystem biodiversity conservation in the GMS have been gradually transformed into ranges of "agricultural" species. With the reduction of natural rainforests and monsoon forests, in many places, natural biodiversity has been changed to human-induced agrobiodiversity.

Forest Inventory data collected in Vietnam shows that the natural forest cover in this state in 1943 was 14,325,000 hectares, while this figure declined to 9,444,198 hectares till 2000. In 1943, there was no planted forest in Vietnam; however, till 2000, the area covered by planted forest has been increased to 1,471,394 hectares. Forest cover decreased from 43.7% in 1943 to 33.2% in 2000, and by 1990 this number used to decrease to 28% [14]. With population's increasing settlements to forest areas, land needed for cultivation have been extended. People regenerate natural forest diverse species for high-yield and monoculture agricultural crop. As chain effects of population settlements and land cultivation, forest habitats are cleared, trees are logged down, plants species are lost, and animals are hunted for food and trading. In other places, such as the Tonle Sap Lake Zone of Cambodia, increasing use of fertilizers has caused significant adverse impacts on fish species in the Great Lake and population health around this zone.

Recent research shows that the greatest opportunities for expanding the current global and regional network of protected areas to fill priority gaps in biodiversity conservation tend to occur in the tropics on larger landmasses and in mountain zones [15]. The Greater Mekong Subregion, fixing both of these factors, is the appropriate setting for creating and managing protected areas for biodiversity conservation. However, because of high human population density, and because most areas in the subregion are fit and valuable for cultivation and farming, it takes both financial and social costs to restrict agriculture and create conservation corridors.

3. BIODIVERSITY CONSERVATION: GAINS AND LOSSES

A Case Study of Xishuangbanna, Yunnan Province, China

Located in Yunnan province of China, Xishuangbanna has been chosen as one of the five GMS BCI pilot sites. By the end of 2005, 193 nature reserves had been established with a total area of 3.74 million ha in Yunnan Province, which cover 8.8% of the provincial territory [16]. Among these reserves, Xishuangbanna National Nature Reserve was established in 1958 which is one of the earliest established nature reserves in Yunnan. It lies in the counties of Jinghong, Mengla, Menghai, south of Yunnan, and covers a total area of 241,776 hectares among which forests cover an area of 197,800 hectares and accounts for 81.8% of the total land of the reserve. However, only 7000 hectares in the 197,800 hectares forest area is natural virgin forests which has never been destroyed by human beings and human activities and accounts for just 2.9% of the total land of the reserve [17]. In 1993, Xishuangbanna was accepted by UNESCO as a member of the International Man and Biosphere Reserve Network. With the promotion of GMS Biodiversity Conservation Corridors Initiative, Xishuangbanna National Nature Reserve, including Menyang, Mangao, Menglun, Mengla, and Shangyong - which are fragmented due to the development of large-scale rubber plantations, has been selected to create a united and unique formation of tropical and subtropical forest extending from Yunnan Province down to the border of Lao PDR through a series of corridors [18].

The main GMS BCI targets for environmental protection in Xishuangbanna is the tropical forest ecosystem, including marvelous virgin forests, tropical rainforests and monsoon rainforests, as well as precious flora and fauna. Although Xishuangbanna covers only 0.2% of the territory of China, the abundant flora there comprises more than 3890 identified species of higher plants and seed plants. Among these plants, 57 species are rare and endangered plant species. In addition, there are over 800 species of medicinal plants and other plants with special use. The reserve is also a home of 429 species of birds, 37 species of amphibians, 68 species of reptiles and 100 species of fish, among which 114 species are rare and endangered animal species.

Xishuangbanna's total population is 840000, and there are 13 ethnic minorities live in this area. Pursuant to the Regulations of the People's Republic of China on Natural Reserves, people are not allowed to inhabit, log, hunt, fish, travel, clear land, mine, or quarry in the core zone of nature reserve. Limited livestock grazing and

non-timber products collection such as medicine collection are allowed in buffer zone. Therefore, local people living in and near the nature reserves are not supposed to get means of livelihoods directly from the reserves. Nevertheless, because of poverty and lack of education, people still commit illegal hunting for food and trading, unlawfully felling, and irrational land clearing for farming and cultivating. As a result, the nature reserves have still been gradually destroyed; people who have been caught of ruining nature reserve may be fined or penalized, and these punishments may cause the poverty situation even worse. What's more, because the nature reserves usually have been created after people's settlement in relevant areas, it is not easy to find a proper strategy of management both realizing the final and complete purpose of establishing nature reserves and improving local people's life quality. One of the commonly used modern strategies in biodiversity conservation management is to migrate and resettle people from protected areas. However this strategy may bring about new ethical problems and economic pressures.

With the human society's development, conflicts have arisen in nature reserve and biodiversity conservation management between wildlife and adjacent communities. One of the conflicts is damage to crops, housing, and even people's lives done by wild animals particularly elephants, bears, and monkeys. According to results with statistics gathered by the Forestry Administration of Xishuangbanna, in 2005 there were 578 villages and 12037 households' crops, sugarcanes, banana plants, and non-timber trees have been eaten or destroyed by wild animals, which has caused direct economic losses of 21,740,000 Yuan. Moreover, twenty people were attacked by wild animals and three of them died. The Law of the People's Republic of China on the Protection of Wildlife provides that local government shall compensate people for the damage done to crops by wild animals. Basing on this provision, the provincial government of Yunnan issued Compensation Rules for the Damage to People and Their Property by Protected Terrestrial Wild Animals in 1998. According to the Compensation Rules, provincial government of Yunnan will provide half of the compensation funds and prefecture and county governments are supposed to finance the other half funds. However, because prefecture and county governments have difficulties in providing money for compensation funds and because of various other reasons, the actual compensation for damage caused by wild animals to sufferers is very low. In 2004, for one kilogram corns, people living adjoining to the reserves could be compensated 0.05-0.08 Yuan while the market price was 1.2-1.4 Yuan per kg; the average compensation fee for a farm cattle was only 70 Yuan; and there would be no compensation for personal injury [19]. This situation has not been ameliorated in recent years, and in other places adjacent to nature reserves in Yunnan Province along the Lancang-Mekong River Basin, the exact compensation fee is the same as Xishuangbanna or even lower.

Benefits-Duties Approaches to Biodiversity Conservation

As discussed, to simply migrate people from nature reserves; forbid them to adversely impact protected areas by punishments; or compensate them once damage done by animals happen could not fully accomplish the ultimate purpose of biodiversity conservation in the subregion and may cause ethical, social, and economic problems. Therefore, we need to find new strategies to help community members change their behaviors from negatively impacting the biodiversity conservation to conserving it. One possibility for this is to establish a benefits-duties model for community members.

To build such a benefits-duties model, emphasis should be placed on both providing benefits that local people may gain from participating in biodiversity conservation and notifying people of their duties and responsibilities to environmental protection and natural resources management. One of the major concerns for this model is whether there is a stable and long-term management system for relevant local people and local communities to create and gain moderate benefits that they may appreciate and as a result solid support from the communities may be given to the government on biodiversity conservation. Here, benefits refer to not only economic incentives but also other forms of profits such as employing local people; creating and providing steady jobs relating to biodiversity conservation; supplying people with better strain crop seeds while teaching them scientific planting methods to raise production; and helping people to install energy saving facilities such as solar energy water heaters to control natural resources consumption. Economic incentives can have an impact when income is relatively high and where income accrues directly to local residents at household level. However, where the financial benefits are small, income generating jobs are relatively few and little opportunity exists to exert any influence over the use of wildlife resources, people continue to consume and trade wildlife illegally [20].

When we create a benefit-sharing model for relevant local people and local communities, we shall also establish a link between the benefit transfers and the biodiversity conservation objectives. Without such linkages, people may fail to understand and realize the purpose of biodiversity conservation behind the benefits they achieve [21]. Thus, the local people should be informed of their responsibilities, duties, and obligations to nature reserves and biodiversity conservation. As people are social actors of biodiversity conservation, differentiation needs to be made with regards to what role each community involved should play in effecting nature reserves and participating in conservation. Consequently, the roles of all stakeholders involved should clearly define duties and responsibilities. On the one hand, local people and local communities are supposed to be part of biodiversity conservation programs, and to manage and be responsible for biodiversity conservation affairs according to their different knowledge towards relevant nature reserves. On the other hand, systematic and consistent legitimacy of

national statutes and legislations as well as local regulations and commands should be constructed both to ordain sanctions and prescribe rights of local people.

4. CONCLUSION

Increasingly, global and regional biodiversity conservation relies on a network of nature reserves and international protected areas which provide basic and essential living conditions necessary for the species' survival. In the human context, the analysis of feasibility of conserving biodiversity and assessment of impediments and threats to biodiversity conservation in the Greater Mekong Subregion help to find strategies to achieve the final targets of the ten year plan of GMS Biodiversity Conservation Corridor Initiative and other natural resources management programs.

It is not an easy task to conserve biological diversity and restore habitats within limited time and areas. With the rapid growth of world's human population and speedy consumption of natural resources, biological diversity will continue to decline and species will continue to be extinct if there is no effective and rational management and reserving structure that considers both conservation purpose and relevant human environment. In the Greater Mekong Subregion, as most people are smallholder population and as the annual income of many local communities are still below poverty line, more intensive research both nationally and internationally should be done to study systematical measures and techniques to realize protection of rare species and sustainable development.

REFERENCES

[1] *Living Beyond our Means: Natural Assessment and Human Wellbeing*. Millennium Ecosystem Assessment [On-line serial]. 2005 from the World Wide Web: http://www.millenniumassessment.org/documents/document.429.aspx.pdf.

[2] Vitousek PM; Mooney HA; Lubchenco J; and Melillo JM. 1997. Human Domination of Earth's Ecosystems. *Science* 277: 494-499

[3] Asian Development Bank. *Greater Mekong Subreign Biodiversity Conservation Corridor Initiatives*. GMS BCI Pilot Sites [On-line serial]. 2006 from the World Wide Web: http://www.adb.org/Projects/GMS-biodiversity.

[4] Pan Zhenqiang. 2006. *China and East Asia Regional Cooperation and Community Building*. Konrad Adenauer Stiftung. KAS-Schriftenreihe. Beijing: 17.

[5] Balmford A. Moor IL; Brooks T; and Burgess N. 2001. Conservation Conflicts across Africa. *Science* 291: 2616-2619.

[6] Institute of Geography, Chinese academy of Sciences. 2006. *The Atlas of Population, Environment and Sustainable Development of China*. Beijing: China Scientific Book Service.

[7] *The World Population Statistics of 2004* [On-line serial]. http://www.popinfo.gov.cn/popinfo/pop_docrkxx.nsf/v_tjzl/EAA14536209E89CA48257049002B7C90.

[8] Sanderson EW; Laiteh M; Levy MA; Redford K; Wannebo AV; and Woolmer G. 2002. The Human Footprint and the Last of the Wild. *BioScience* 52: 891-904.

[9] Asian Development Bank. 2007. *GMS Biodiversity Conservation Corridors Initiative Strategic Framework and Technical Assessment* [On-line serial]: http://www.adb.org/Documents/Reports/GMS-BCI/.

[10] David E. Thomas. 2003. Montane Mainland Southeast Asia: A Brief Spatial Overview. *Landscapes of Biodiversity*. Kunming. China: 25-40.

[11] David E. Thomas; Horst Weyerhaeuser; and Pornwilai Saipathong. 2003. Improved Tools for Managing Agroforestry Landscapes in Northern Thailand: Pilot Application of Spatial Analysis and Negotiation. *Landscapes of Biodiversity*. Kunming. China: 381-403.

[12] Tilman D; D'Antonio C; Dobson A; Fargione J; Howarth R; Schindler D; Schlesinger WH; Simberloff D; Swackhamer D; and Wolff B. 2001. Forecasting Agriculturally Driven Global Environmental Change. *Science* 292: 281-284.

[13] Green RE; Cornell SJ; Scharlemann JPW; and Balmford A. 2005. Farming and the Fete of Wild Nature. *Science* 307:550-555.

[14] FIPI(1995), State Directive Commission of Forests Inventory. 2001. Vietnam.

[15] L. J. Gorenflo and Katrina Brandon. 2006. Key Human Dimensions of Gaps in Global Biodiversity Conservation. *Bioscience* 56: 723-731.

[16] State Environmental Protection Administration of China. 2006. *China Nature Reserves 2005*. Beijing.

[17] People's Daily—Overseas Edition. April 14th 2001. China.

[18] GMS Biodiversity Conservation Corridors Initiative Pilot Project Profile: Xishuangbanna, People' Republic of China. 2006. *GMS Core Environment Programme* [On-line serial]. 2006 from the World Wide Web: http://www.adb.org/Projects/core-environment-program/pilot.asp.

[19] Li Xikun. 2004. Studies on Legal Problems in GMS Biodiversity Conservation. Yunnan: 7.

[20] Binswanger; Hans P.; Aiyar; and Swaminathan. 2004. Scaling up Community-Driven development: Theoretical Underpinnings and Program Design Implications. *Papers of the World Bank* [On-line serial]. 2006 from the World Wide Web: http://ideas.repec.org/p/wbk/wbrwps/3039.html.

[21] Emma Algotsson. 2006. Wildlife Conservation through People-Centered Approaches to Natural Resources Management Programmes and the Control of Wildlife Exploitation. *Local Environment* 11: 79-93.

GMSARN International Journal
NOTES FOR AUTHORS

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In the Greater Mekong Subregion, home to about 250 million people, environmental degradation - including the decline of natural resources and ecosystems will definitely impact on the marginalized groups in society - the poor, the border communities especially women and children and indigenous peoples. The complexity of the challenges are revealed in the current trends in land and forest degradation and desertification, the numerous demands made on the Mekong river - to provide water for industrial and agricultural development, to sustain subsistence fishing, for transport, to maintain delicate ecological and hydrological balance, etc., the widespread loss of biological diversity due to economic activities, climate change and its impacts on the agricultural and river basin systems, and other forms of crises owning to conflicts over access to shared resources. The *GMSARN International Journal* is dedicated to advance knowledge in energy, environment, natural resource management and economical development by the vigorous examination and analysis of theories and good practices, and to encourage innovations needed to establish a successful approach to solve an identified problem.

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