An Ecological Evaluation Approach For Dam Project Development In Malaysia

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Abstract: Dams are built to provide water for irrigated agriculture, domestic or industrial use, to generate hydropower or help control floods. Decisions to build dams are made, as human knowledge and experiences expand and new technologies develop, parallel with the fact that the decision-making process is also increasingly becoming more open, inclusive and transparent. Despite the benefits provided by the dams to humankind, much environmental damage has occurred as a consequence of these projects. In particular, dam projects often lead to considerable changes in the natural ecosystem. As the changes are related to the fundamental ecological issues, ecological input should be mandatory and play a major role in all dam project decisions. This paper looks into various studies on the application of ecological evaluation methods in regards to the EIA for the land-use development projects, particularly the dam projects. It details the limitation and challenges faced by the ecological evaluation. Alternative approaches are considered and elucidated as the way forward to enhance the ecological evaluation framework. Towards this end, an ecological evaluation method for the EIA of dams based on ecosystem rarity is proposed. This method allows the loss and fragmentation of the ecosystem of the alternative dam site to be determined in an objective and replicable way.

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1. Introduction

Ecological evaluation presumably seeks to provide a quantitative statement of worth which a competent ecologist attributes to a particular biological system. In the light of this definition, two types of ecological evaluation can be discerned. Firstly, ecological evaluation serves as an assessment of ecosystem qualities per se, based on the thought that some ecosystem attributes are more important or interesting than the other, regardless of their social interest. Secondly, ecological evaluation functions as a socio-economical procedure to estimate the function of the natural environment for human society (Van Der Ploeg and Vlijm 1978; O'Connor 1974; Geneletti 2006).

Therefore, ecological evaluation is considered one of the most important components in producing the Environmental Impact Assessment (EIA) of any land use projects such as dams, which pose an adverse impact on areas with considerable nature conservation interest. Husnain (2012) highlights the incomplete ecological evaluation as part of the root cause of the poor performance of the EIA in dam development projects, where unwise decision-making leads to the destruction of habitats, biological diversity, ecological services, agricultural lands and livelihood resources.

As more and more dams are being built throughout the world due to the increasing human demand for water, energy and other water-related services, more and more natural ecosystems with high ecological significance would be diminished. There are more than 45 000 large dams around the world which play an important role in helping communities and economics harness water resources for food production, energy generation, flood control and domestic used, as shown in Table 1.

In Malaysia, 80 dams have been built (Department of Water Supply, 2012) and 12 hydropower dam projects have been planned for implementation for the period of 2008 until 2020 (Sarawak Electrical Supply Cooperation, 2009). Table 2 shows the majority of dams in Malaysia aiming to supply water. However, there is growing interest in dams for flood protection, recreation, tourism, and aquaculture and in pumped storage dams for power generation to meet peak demand in Malaysia. Single-purpose hydropower dams are the most common in the states of Sarawak and Perak, whereas single-purpose water supply projects dominate in most of the states of Peninsular Malaysia including Sabah. In short, dams are promoted as an important way to meet water and energy needs and support economic development even though the environmental impacts tend to be left outside the assessment framework and the role of impact assessment in project selection has remained marginal.

A study conducted by Sarawak Electrical Supply Cooperation (SESCO) and a group of West German and Swiss Consultants (1979) identifies a total of 155 potential dam sites in the state of Sarawak, Malaysia.

However, this potential cannot be fully harnessed because some of those sites are mutually exclusive, that is, the construction of some sites will entail the creation of reservoirs that will submerge the other upstream sties which are rich in ecological diversity and which go beyond monetary value. Thus, a subsequent evaluation of the optimum development chains for all the river catchments is carried out to determine the best means of harnessing their respective hydropower potentials. The study has further found out that a total of 51 hydropower dam projects could be developed (Abdul, 2007).

Table 1. Distribution of existing large dams by region and purpose

Region	Purpose (%)					
	F	I	W	HP	OSP	MP
Africa	1	52	20	6	2	19
North America	13	11	10	11	24	30
South America	17	15	13	26	4	25
Asia	2	65	2	7	1	24
Austral-Asia	2	19	44	19	3	14
Europe	3	25	16	31	2	23

Source: International Commission on Large Dams 1998; World Commission on Dams 2000
Note on Function:
F : Flood Control
I : Irrigation
W : Water Supply
HP : Hydropower
OSP : Other Single Purpose
MP : Multipurpose

Table 2: Distribution of major dam projects in Malaysia

State	Reservoir Name	Year	Function
Perlis	Timah Tasoh	1987	I/W/F
Kedah	Padang Saga	1964	I/W/F
	Muda	1966	W/I
	Pedu	1966	W/I
	Ahning	1985	W/I
	Malut	1987	W
	Beris	2000	I/W/F
Pahang	Berapit	1896	W
	Bukit Panchor	1931	W
	CherokTo'kun	1834	W
	Air Hitam	1962	W
	Mengkuang	1985	W
	TelukBahang	1999	W
State of Federal Territory, Labuan	Bukit Kuda	1985	W
	Kerupang	1985	W
	Sungai Pagar	1985	W
Kelatan	Bukit Kwong	1984	I/W
	Pergau	1996	HP
Terengganu	Kenyir	1984	HP/F

Table 2: Distribution of major dam projects in Malaysia (cont.)

State	Reservoir Name	Year	Function
Selangor	Air Kuning	1934	RC
	Sungai Baru	1934	RC
	Tasik Subang	1950	W
	Klang Gates	1959	W/F
	Langat	1976	W
	Semenyih	1982	W
	Batu	1985	W/F
	Sungai Tinggi	1995	W/RR
	Sungai Selangor	2001	W/RR
Melaka	Air Keroh	1890	RC
	Asahan	1932	W
	Durian Tunggal	1974	W
	Bunded Storage	1991	W
	Durian Tunggal JUS	2003	W
Perak	Bukit Merah	1902	WW
	Chenderoh	1930	HP
	Gopeng	1961	Sr
	Mahang	1968	HP
	Jor	1968	HP
	Temengor	1977	HP
	Bersia	1983	HP
	Kenering	1984	HP
	Air Kuning	1991	W
	Sultan Azlan Shah/ Sg. Kinta	1902	W
Sabah	Pinangsoo	1984	W
	Sepayaga	1984	W
	Timbangan	1984	W
	Tenom	1997	HP
	Babagon	1984	W
Johor	Labong	1947	I/W
	GunungLedang	1959	W
	Congok	1960	W
	Mahang	1968	HP
	Lebam	1979	W
	Macap	1980	W/F
	Sembrong	1981	W/F
	Layang (Lower)	1985	W
	Layang (Upper)	1985	W
	Bekok	1987	W/F
	Juaseh	1992	W

Table 2: Distribution of major dam projects in Malaysia (cont.)

State	Reservoir Name	Year	Function
Sarawak	Sika	1981	W
	Batang Ai Hydro-electric Station	1985	HP
	Assyakirin	2004	W
	Gerugu	2004	W
	Kelalong	2009	W
	Bakun	2012	HP
	Bungoh	2012	W

Source : Department of Water Supply, 2012
Function
RR : Regulating Reservoir RC : Recreational
Sr : Silt retention W : Water Supply
HP : Hydropower I : Irrigation
F : Flood Control

Electricity generation constitutes an important reason for building dams in Malaysia particularly in the state of Sarawak, either as the primary purpose, or as an additional function where a dam is built for other purposes. Hydropower represents the largest, indigenous, renewable energy resource in Malaysia. Most of the hydropower potential lies in the state of Sarawak which has a total exploitable potential of 87,000 GWh per year, which is about 70% of the total potential of 123,000 GWh for the whole country (Sarawak Electricity Supply Cooperation, 2008). With a view to meet the power demand for the Sarawak, as well as those in Sabah and Peninsular Malaysia, 12 hydropower dam projects have been planned for implementation from the period of 2008 until 2020. The hydropower dam projects will provide reliable and renewable bulk energy at a total installed capacity of about 7000 MW. The locations of these dam projects are shown in Table 3.

Despite all these benefits, dam developments come under increasing scrutiny during the past decade. Among the primary questions that have arisen are: Are damages to the ecosystem, particularly related to species being pushed towards extinction, really worth the benefits? Is the lesson learned from other countries being considered, and in tandem with the design and operational rules of new dam projects in Malaysia, particularly related to long-term environmental consequences? The current state of knowledge indicates that dams, particularly large dams have mostly negative impacts on the ecosystem. These impacts are complex, varied and often profound in nature. In many cases, dams have led to the irreversible loss of species populations and ecosystem because the ecosystem impacts are complex and it is hard to establish a common and standardized ecological evaluation framework. This makes it difficult for any relevant party to give a precise and detailed prediction of change subject to the result from the construction of a dam or series of dams.

Table 3: The status of 12 hydropower dam projects in the State of Sarawak, Malaysia

Project	Installed Capacity (MW)	Status
Murum	944	Construction
Batang Ai Extention	80	Under tender
Baram	1,000	Feasibility study
Baleh	1,400	Feasibility study
Limbang	150	Feasibility study
Lawas	105	Feasibility study
Metjawah	300	Feasibility study
Belaga	60	Feasibility study
Ulu Ai	54	Tender design completed
Belepeh	110	Basin Study
Linau	290	Basin Study
Tutoh	220	Basin Study

Source: Sarawak Energy, 2008

Nauman (2003) discusses a case of reservoir (dam) construction in an ecologically rich area of the province named Sindh in Pakistan, which has not only ravaged the ecological habitats but also diminished the natural resource which has been the source of dependency for the poor locals for livelihood. In the light of these concerns, the ecological evaluation of dam projects needs to be strengthened and emphasized as to provide the criteria and information that can be used to support decision-making by the relevant authorities in regards of natural conservation. By identifying the most ecologically valuable areas, planning and management practices can be applied as to maintain the areas of value (Smith and Theberge, 1987). Among the main concerns that have arisen include the significant treatment given to the conservation of biodiversity. The dam project influences the abundance and distribution of the biodiversity of the area impacted. In particular, the dam projects and other related activities often cause an adverse impact on natural landscapes and the ecological loss as well as contribute to the ecological fragmentation.

Despite the importance of the ecological component, the standard methodology for performing the ecological evaluation with regards to the EIA procedure is still lacking (Roome, 1984). For instance, the boundary of the dam project has been delimited. As a result, whatever features that lay outride its boundary will not be considered during the impact analysis. Besides, the ecological evaluation tends to emphasize on the designated site only. This will create a substantial gap between the recommendation provided by the scientific forum and the natural application. Scientific guidelines and methodological papers stress the relevance of extending the analysis so as to depict the overall ecological significance of the area (Geneletti, 2003).

The ecological evaluation with regards to the EIA of dam tends to restrict the analysis to one level of biodiversity only without providing any scientific justification for doing so. In short, the ecological evaluation does not involve a complete treatment of biodiversity levels. These include the failure to address several key issues; such as the impact of habitat fragmentation on wildlife population upstream of the dam and the isolation of population on the other side of the reservoir which in turn, may greatly affect population viability and genetics. The EIA also fails to address the magnitude of the loss of fish species upstream and downstream of the dam and how this loss would affect the regional biodiversity. Furthermore, floral and faunal surveys focus on the inundation area only; and the assessment of impacts does not consider the ecological needs of individual species or communities identified in these surveys.

2.0 Ecological Evaluation Methodology

The main purpose of an ecological evaluation can be manifested in the conservation of nature. It includes the maintenance of nature areas and their biodiversity, and the maintenance of the social functions as well as the intrinsic values provided by the natural areas in the form of educational, cultural, scientific and recreational values. Therefore, it is important to establish the ecological evaluation framework that can address those objectives. The criteria most often used to assign habitat values in the ecological evaluation include species diversity, species rarity, naturalness, size, threat of human interference, representativeness, research and educational value, recorded history and potential value (Geneletti, 2005; Margules and Usher, 1981).

Most of the ecological evaluation methodologies focus on the use of modelling. For instance, the spatial prediction of species distributions from habitat models has been used in the ecology over recent decades for a variety of purposes including predicting loss and fragmentation of habitat (Powell et al., 2010), testing of ecological theory (Oksamen and Minchin 2002; Minchin 2002; Austin et al., 2006), biological processes (Battaglia and Wiliams,1996; Leathwick and Austin, 2001), resource management (Borchers et al., 1997; Williams et al., 2000; Moisen and Frescino, 2002), and biodiversity conservation (Wintle et al., 2005; Rodriguez et al. 2007; McAlphine et al. 2008).

Moreover, it is essential to determine the ecological value of the landscape beyond protected areas in which the development results in a piece of land being transformed from its 'natural' state to an alternative state (e.g. industrial, agricultural, dams and reservoirs). Consequently, Willis et al. (2012) have established a model to evaluate the five primary criteria of importance for the ecological valuation of a landscape. The criteria are: biodiversity, vulnerability, fragmentation, connectivity and resilience. These criteria represent the current ecological properties of the landscapes (e.g. biodiversity, threatened species) and the key features important for supporting ecosystem functions (e.g. connectivity, migration routes, wetlands, corridors), habitat integrity and resilience.

On the other hand, Piekielek et al. (2012) have developed methods to determine the extent of fragmentation of coarse-site habitats in and around US National Parks so as to understand the effect of land use change and other forms of circumstances on habitat types. The area of analysis for each park is defined by a protected area centred-ecosystem and is done following the methods of Hansen et al. (2011). Furthermore, the studies focus on land use because there is a realization that its ecological effects on parks are understudied (Hansen and Defries 2007) and unlike other drivers of changes, there are ample opportunities to ameliorate the adverse effects. However, focusing only on the ecological effects of land use change and not on the other possible modes of habitat degradation that may be important in these study area can affect the interpretation of the results. This is because the habitat could be severely threatened by degradation brought about by a change agent other than land use.

Laurance and Yensen (1991) develop the first generalised predictive model estimating the amount of an edge-affected area and a remaining unmodified core area in isolated fragments. Despite their conclusion that the core-area model should be applicable to all fragments, regardless of the size or shape, the model has never been validated beyond the limited range of parameters under which the model is constructed. Didham and Ewers (2012) conclude that past predictive application of the core-area model has underestimated the true core area and produced significant overestimates of the edge-affected area.

Generally, there are yet many discussions on the efficiency and validity of the different evaluation techniques for the ecological evaluations (Van Der PloegandVlijim, 1978; Getmark et al., 1986; Usher, 1986; Geneletti 2006). To this end, the authors propose an approach based on the ecosystem rarity for the ecological evaluation with respect to the biodiversity Impact Assessment of Dams. The selected criteria (rarity) can be measured for an ecosystem type in an objective and replicable way (Geneletti 2006). Furthermore, the use of the rarity criterion for the ecological evaluation resides in the fact that the rarer a feature is, the higher its probability of disappearance. Smith and Theberge (1986), Margules and Usher (1981), and Geneletti (2006) have pointed out that rarity is the most commonly used criterion when assessing the relevance of an ecosystem for biodiversity conservation. This approach consists of a baseline study, encompassing the ecosystem mapping and impact analysis of ecosystem-loss and ecosystem fragmentation (Geneletti 2003).

2.1 Baseline study

The baseline study is vital due to the fact that it normally involves the gathering of relevant data which are subsequently used for the impact analysis. Grostan et al. (2006) state that any ecological assessment of an individual site or groups of site rest fundamentally on the baseline against which they are being measured, such as the genetic diversity, population viability or species composition at a particular site, over a particular area or in a particular year(s). The key-data generated during this stage are represented by the map of the natural ecosystems occurring within the study area. This map is used as the basic reference to identify the impacts caused by the dams and to estimate their significance. The classification of vegetation types is done based on CORINE legend (European Commission, 1993) as well as by Scott et al., (1996) and Aranha et al., (2008).

The ecosystem map produced is likely to contain misclassifications. Geneletti (2006) has pointed out that the identification of the patch boundaries is certainly one of the most critical issues related to the accuracy of the ecosystem map. This issue is very significant in the prediction of the space-occupation impact of the different dam site alternatives. Therefore, the uncertainty analysis based on fuzzy boundaries (Zadeh 1965; Burrough and McDonnell 1998; Geneletti 2006) on the identification of the boundaries of the natural ecosystem patches occurring within the study area needs to be performed. In addition, an accuracy assessment needs to be performed on the map to generate a confusion matrix. The confusion matrix shows the accuracy and the reliability with which each cover type has been classified. Reis (2008) adds that the most common way to present the accuracy of the classification result is through this confusion matrix.

2.2 Impact Analysis

Many planning decisions carried out in the infrastructure and other development issues that arise can become the causes for the fragmentation of natural habitats which result in both habitat loss and isolation, as well as habitat degradation (Opdam and Wein, 2002; Gontier et al., 2006; Monavari et al., 2010). The report of the World Commission on Dams (2000) has stated that to date, over 400,000 km2 of the earth have been flooded due to damming, and the direct impacts include habitat loss, the elimination of flora and fauna and, in many cases land degradation. It is also stated that an estimated 60% of the world's large river basins are highly or moderately fragmented by dams. For these reasons, two types of impact caused by dam projects on the natural ecosystem have been considered. Those impacts are the loss of the ecosystem and the fragmentation of the ecosystem. The impact analysis is done by using the input data which are generated from the ecosystem map, the space-occupation map (the map representing the sources of disturbance such as settlements, infrastructures and logging) and the layout map of the proposed dam projects. The direct loss of the ecosystem can be predicted by overlaying a space-occupation map of the proposed dam projects with the ecosystem map. Consequently, the ecosystem loss impact caused by the dam projects for each dam project alternative would be quantified by multiplying the value of each ecosystem type for its predicted area loss and by summing up the result (Dee et al., 1972; Smith and Theeberge, 1986; Geneletti, 2002; Monavari, 2010).

For the prediction of ecosystem fragmentation, three patches of indicators were selected which include the core area (the size of each ecosystem patch), disturbance (the average distance from the surrounding settlements, infrastructures and logging) and isolation (the average edge-to-edge distance from the surrounding ecosystem patch) (Geneletti, 2002; Monavari et al., 2010). Those three indicators are used because they are capable of expressing a full range of fragmentation effects besides providing a straight forward interpretation. All three indicators have been used as indirect measure of ecosystem viability. Viability can be defined as the ability of an ecosystem to preserve its integrity and host its original biodiversity (Geneletti, 2002). In general, the bigger, the more connected and the further from human disturbance an ecosystem is; the higher is its viability (Noss et al., 1997; Saunders and Hobbs, 1991; Geneletti, 2006). In order to assess the ecosystem fragmentation, the ecosystem viability has to be assigned (Treweeh and Veitch, 1996; Geneletti, 2002; Monavari, 2010). Subsequently, the fragmentation impact score can be calculated by multiplying the losses in viability by the value of the affected ecosystem and then by their remaining area. This approach allows the aggregation of the impact map into the synthetic impact score which is useful for comparing the performance of the different alternatives.

3.0 Ecological Evaluation Issues and Challenges

Focusing on the current ecological evaluation of dam projects in Malaysia, the main issues and challenges are discussed under the sub-headings of the baseline study, impact prediction and impact assessment.

3.1 Baseline Study

Baseline study is contained in the description of the environmental setting of the area relevant to biodiversity conservation that is likely to be affected by the proposed dam projects. This involves the collection and the processing of all the relevant thematic data which will be used for the subsequent impact prediction and impact assessment stages. The ecological impacts of the dam project can be predicted and assessed only if the relevant features have been included in the baseline study. Thus, the baseline stage provides a very significant role in producing a sound ecological evaluation with respect to the environmental impact assessment. The study area is the area that is potentially affected by the presence of the dam projects and should be established during the baseline study. Despite its relevance, the identification of the study area is done based on a non-ecological basis which consequently undermines the effectiveness of the subsequent impact analysis. As an example, none of the EIA of the dam projects in Malaysia has discussed thoroughly the definition of the study area from the ecological point of views. In particular, a review of the EIA of the Bakun Hydroelectric Project by the International River Network (1995) has highlighted the fact that the assessment of the impact of vegetation resources is limited following the loss of vegetation in the inundation zone and that it focuses particularly on the loss of the economically important timber species.

The geographical boundary of the study area should be dictated by the expected spatial influence of the impact that can be predicted. As a result, it is important to define the boundary of the study area based on an ecological basis, rather than in an arbitrary manner. However, the area under study during the baseline stage, and consequently during the impact analysis is limited to the inundated zone with the reservoir area. As a result, data collection and mapping are restricted to one artificially drawn boundary; regardless of the actual spatial spread of ecological processes (Geneletti, 2002). This, in turn will marginalize the potential effects which occur in a broad range, such as the fragmentation of the ecosystem. For example, a review conducted on the baseline conditions of Beris Dam project indicates that the documents generally provide a superficial description of the environment, covering most elements but yet, fail to provide any explanation on the environmental links and inter-relationships particularly between the ecology and other environmental components (Nik Norulaini et al., 2006). Another review conducted on the impacts on the Environmental and Ecological Diversity of Chotiari Reservoir in Pakistan reveals that the report has absolutely failed to identify the indirect and secondary impacts on biodiversity due to poor and inadequate guidelines on the methodology of impact scoping especially on the impact identification and prediction (Husnain and Wende, 2010).

The selection of the features to be studied and mapped within the study area is vital. Therefore, whatever lies within the study area will be considered in the subsequent impact analysis. There is a significant gap between the recommendations provided by the scientific forum and the actual applications. Scientific guideline and methodological papers place an emphasis on the relevance of extending the analysis so as to depict the overall ecological significance of the area (Geneletti, 2002). Unfortunately, the EIA tends to focus on the selected features only, such as sites already designated for nature conservation. For instance, a review of the EIA of the Bakun Hydroelectric Project indicates that, flora and fauna surveys focus on the inundation area only, and the assessment of impacts does not consider the ecological needs of individual species or communities identified in these surveys (Philip et al., 1995).

The EIA (Order 1987), procedure and requirement in Malaysia for the environmental assessment of the dam projects under the National Water Resources Master plans emphasises the importance of considering the overall ecological value of the area through which the dams or reservoirs are to be built. This is due to the fact that the ecological dynamics not only associate within the boundaries of the study area but also beyond the site boundaries. Furthermore, ecological dynamics are directly influenced by disturbance affecting the surrounding environment. Therefore, it is wise to consider that all natures are valuable and also wise to apply a holistic and comprehensive approach for analysing the effect of dam projects. Focusing on the inundated zone and selected features only implies disregarding the fundamental ecological dynamics of the whole landscape of the study area. Despite the significant contribution of the ecological value to the country's natural capital, the EIA practice focuses on the analysis of the potential impacts on designated sites and frequently fails to consider the dynamics of the habitat and species beyond the boundaries of the study area. A review of British EIAs (Byron 2000) acknowledges that limiting the evaluation on the site in question and species that are formally protected is still commonplace. Similar conclusions are drawn by Kolhoff (2000) in his study on biodiversity and the EIA in Netherlands which highlight the limitation of ecological evaluation beyond the designated site.

3.2 Impact Prediction

The construction of dam projects in Malaysia has forced adverse impacts on the environment particularly the biodiversity. The sites and watersheds are within the core area for strict biodiversity conservation, and the dams and related facilities are close to, and available within, eco-regions, key biodiversity areas, and conservation corridors in one of the world's centre of plant diversity. The two significant impacts considered in this article are habitat loss and habitat fragmentation. The direct loss of habitat caused by the dam projects is relatively straightforward to predict. However, the fragmentation of habitat patches into smaller and more isolated units is a more complex issue and its estimation necessarily involves a higher degree of uncertainty (Genelletti, 2006).The direct loss of habitat refers to the land conversion from the original lower to an artificial cover, while the total amount of land that is to be occupied by the completed infrastructure scheme is defined as "land-take" (Treweeh, 1993; and Byron, 2000).

The habitat loss is being predicted based on the documentation and guidelines prepared and adopted by various development agencies and at the federal and state levels such as the Environmental Impact Assessment Guideline for Dam and/ or Reservoir Guidelines for Dam and/ or Reservoir Projects (1995). In addition, the international laws or guidelines as well as the scientific literature are being incorporated in the prediction of the impacts. Despite the availability of those documentations and guidelines for the impact prediction, the computation of the actual amount of land that is to be occupied by the completed dam projects or reservoirs is less simple than it may appear. The size of the dams is normally known after the project blueprints, where the total area that is to lose its original vegetation cover is likely to be broader. This is due to the alteration of the surrounding area during the construction and the activities of other related infrastructure. Furthermore, the actual inundated zone and the new lake edge would be known after the impoundment process is completed.

Based on the analysis of the EIA of dam projects in Sarawak, the author has highlighted that the technical parameters of the dams are normally clearly indicated, but the expected amount of land that is to be occupied by the completed dam projects including the inundated zone is not quantified during the impact prediction process. Therefore, the data of the impact are vague and difficult to be justified. There will always be a flood larger than the design flood that can occur within the river system, even though statistically the chances are very small. These failures are not posing a threat to life, but can create extensive property and ecological damage (Lemperiene, 1993).

Another impact of the dam projects which poses the greatest threat to biodiversity is the fragmentation of the ecosystem. There is a vast ecological literature demonstrating the ecological importance of the integrity of the habitat and infrastructures and the impact of the fragmentation on biodiversity. In general, the greater the patch size, the higher its functionality (Willies et. al., 2011). Manuals of good practices and guidelines which explicitly encourage the consideration of those impacts have been established in the Environmental Impact Assessment Guidelines for Dams and/ or Reservoir Guidelines for Dam and/ or Reservoir Project DOE 1995. Unfortunately, the operational guidance on how to perform a prediction of the fragmentation impacts caused by the dam project is still lacking. This is because fragmentation itself represents a very complex effect, which modelling can be still considered in an experimental phase (Bogaert et al., 2000). A number of scientific journals and publications have discussed the impact caused by the fragmentation of the natural ecosystem (Gonzales et al., 2002; Augett, 2005; Gasto et al., 2006; Willis et al., 2011). However, those contributions tend to focus on modelling the response to the fragmentation of individual species or communities, being mostly oriented to site-related conservation plans (Geneletti, 2006). Didham and Ewers (2012) use the Laurance and Yensen's (1991) core area model to predict its edge effects in fragmented habitats. They highlight the inability of the model to consider the shape variation in large fragmentation with very high shape complexity. The impact prediction in EISs is still generally prior in particular the measurement of spatial indicators, such as habitat connectivity, size and shape, to quantify the effects of fragmentation is uncommon (Byron, 1999; Byron et al., 2000; Geneletti, 2006).

The EIA of dam projects in Malaysia has cited fragmentation but unfortunately, no indicators have been used to measure it. A similar conclusion has been drawn by Geneletti (2002) and M elloni (2004) who state that in the Italian EISs reviewed, indicators for fragmentation were computed only in one case and about 75% of the EISs of infrastructure development did not even mention fragmentation as a possible effect, whereas the remaining 25% did mention fragmentation but no measurement had been done to justify its impact.

3.3 Impact Assessment

Impact assessment involves determining the value of the effect features of natural ecosystem. It involves the transformation of data collected in the baseline study and subsequently the impact prediction into an expression of how the environment should be treated. However, the prediction and assessment are actually rarely explicitly treated as a separate stage. The development of mitigation measures is normally based on the predicted impacts and not based on the results of the assessment of the impact. For instance, Williams et al. (1995) in their review of the EIA of Bakun Hydroelectric Project have highlighted two impacts left to the vegetative resources resulting from the inundated and permanent loss of 69, 640 hectares of agricultural and forest areas upstream of the dam which encompasses the loss of vegetation and habitat and the loss of economically important timber resources.

The mitigation measure proposed for these impacts is reforesting agricultural land above the inundation zone and salvaging "totally protected" species. Thus, the mitigation measure is developed based on the prediction of impact without considering the scope of the impact assessment. It is not clear whether to adopt the measure or that the implementation of the proposed measure is technologically feasible or capable of providing the ecological services displaced by the inundation of the lowland area. Furthermore, there is no proper assessment or habitat fragmentation, reduction of habitat diversity, loss of regional biodiversity and introduction of alien plants and animal species. Reforestation alone will not be able to restore the nature landscape of the impacted areas. Fischer et al. (2006) state that some components of biodiversity or ecosystem cannot reasonably be re-created, restored or rehabilitated especially for old-growth forests, peat lands, slow-breeding or very demanding species. Quetier and Lavorel (2011) have concluded that the unique characteristics, location and history of the impacts on the animal and plant populations, biotic communities and ecosystem properties cannot be replicated.

Assessing the direct habitat loss involves the evaluation of the significant differences between the pre-project and the post-project conditions. It implies the rules to aggregate the habitat values into concise impact score. The impact score is derived from the comparison of the performance of different alternatives (Rivas et al., 1996; Haff, 1996; Genelleti, 2006; Monavari et al., 2010). Unfortunately, the assessment of different losses of the ecosystem in the ecological evaluation with regards to the EIA of the dams in Malaysia does not adopt this approach and the conclusions are usually drawn on the basis of the analysis of the single impacts on the different habitat types. The dam projects not only cause the loss of natural ecosystem but also increase patch isolation, decrease patch size and increase patch exposure to external disturbance that leads to ecosystem fragmentation. Assessing fragmentation implies assessing those features in terms of quality and its relevance to biodiversity conservation. Analysing fragmentation is rather a complex task, which requires the assessment of the habitat values and subsequently the assessment of to what extent such value is being reduced. Furthermore, not all species are affected by fragmentation in the same way: while some show marked declines and local loss, some may change in their abundance and some are even advantaged (Nally et al., 2000).

As discussed earlier, none of the EIAs of the dam projects in Malaysia has predicted and quantified fragmentation in a convincing way. Thus, the actual fragmentation assessment is rarely done as commensurate in the National EIA Guideline for Dam and/or Reservoir (1995). Even the works that develop quantitative approaches to predict fragmentation by means of spatial indicators have failed to adequately address the assessment stage (Geneletti, 2006). Didham and Evens (2012) conclude that in heavily-fragmented landscapes, the spatial complexity of irregularly-shaped habitat patches embedded in contrasting land-use types makes it challenging to estimate the impact of edge effects with any degree of accuracy.

4.0 The way forward

Many efforts are being pursued to address the issues surrounding the ecological evaluation within the EIA. As mentioned earlier, ecological evaluation seeks to provide criteria and information that can be used to support decision-making in biodiversity conservation. Among the paramount effort exerted by international community is the convention on Biological Diversity, ratified by 128 countries, an event that explicitly recognises the link between biodiversity conservation and sustainable development. It acknowledges that biological diversity is more than just the sum of species numbers; it encompasses the variety, variability and uniqueness of genes and species and of the ecosystem in which they occur. The convention's overall objectives include conserving the biological diversity entailing the sustainable use of its components, and the fair and equitable sharing of the benefits that arise out of its utilisation.

Following the establishment of the International Convention on Biological Diversity, attempts have been made in many countries to measure and value biodiversity (McCartreyetal. 1999; McNeely, 1998; Pearce da Moran, 1994; Barbier et al., 1995). In the light of the importance of the biological diversity and their values, several methodological shortcomings in ecological evaluation should be improved. Developing methodologies and procedures for integrating nature aspects with social and economic components in assessment studies is one of the needs to be prioritized. Baseline data availability remains a recurrent problem in the ecological evaluation. Systematic and structured collection and collation of information would not only improve the availability of the baseline data, but they also aid the prediction and evaluation as well as make the use of resources more cost-effective. The need for better data management is recognized, particularly in view of the increasing use of the remote sensing and computerized information storage and retrieved systems. There is an increasing recognition of the need to establish several efficient and effective procedures for reviewing the results of Ecological evaluation within the EIA studies. A major consideration in this respect is a greater recognition of the importance of, and the need for, communicating ecological evaluation results in a clear and concise language in a useful and understandable format. This should facilitate greater involvement of the public, particularly the informed public in defining the scope of an assessment as well as in evaluating and reviewing the results of the ecological evaluation which is deeply embedded in the EIA to facilitate decision-making for the proposed dam developments.

Since the establishment of the Environment Quality Act, 1974 and the accompanying regulations and orders such as the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment): Order 1987 and the Environmental Impact Assessment Guideline for Dams and/ or Reservoir Project (1995), Malaysia has carried out considerable research on the impact of dam projects on the ecology and the environment. Unfortunately, those researches are mainly confined to microscopic quantitative statements rather the microscopic quantitative works, and are focused more on the analysis of impacts on the existing ecology and environment than on forecasting, in terms of analyzing ecological and environmental effectiveness. Insufficient attention is paid to the ecological evaluation of the impacted ecosystem while more emphasis has been placed on returns on power generation, flood prevention and irrigation.

In order to establish an ecologically friendly dam, Malaysia needs to focus on the development and enhancement of the ecological evaluation based on built dams. It is of great significance to perform an ecological assessment of built dams due to the fact that, it allows us to summarize the extent and degree of impact that dam projects exert on the ecology and the environment. Moreover, it also of great significance for the production of pertinent measures for the mitigation of environmental impacts, and to the provisions of systematic preliminary data for designing and constructing ecologically-friendly dam projects in Malaysia.

The application of ecological evaluation for the dam and reservoir developments in Malaysia is still scarce. A concerted effort needs to be made to establish a sound ecological evaluation framework. The framework must specify the objectives of the evaluation, the criteria used to express the degree of achievement of such objectives, as well as it must provide the much-needed guidance on how to measure and assess each criterion with respect to its significance for nature conservation. Only then, the operation of ecological evaluation can be utilized for the dam developments in Malaysia so as to provide rational and sound ecological information in the making of a better EIA. Drawing on the above discussions, some recommendations for selected actions that would enhance the application of ecological evaluation on dam developments in Malaysia are established below:

(i) the establishment of an agreed baseline for the assessment of ecological aspects of the river-catchment where the dam projects have been proposed.

(ii) the detailed evaluation of the ecological composition and representativeness of the river-catchment, across a broad range of environmental and biodiversity features.

(iii) the development and population's database containing information on the occurrence and status of a species of the conservation concerned and other important biodiversity features on the area where the dam projects have been proposed.

Conclusion

Dams generally have extensive impacts on rivers, water catchments and aquatic ecosystem. The ecosystem impacts are more negative than positive and they have led, in many cases, to irreversible loss of species and ecosystem. To date, the efforts to counter the ecosystem impacts of dams have met with limited success, owing to the lack of attention on the anticipation and avoidance of impacts, the poor quality and uncertainty of predictions, the difficulty of coping with all impacts, and the only partial implementation and success of mitigation measures.

The baseline data availability remains a recurrent problem in the ecological evaluation and this can only be minimised through systematic and structured collection and collation of information with the support of remote sensing and computerized information storage and retrieved system. Even with the establishment of the Environmental Quality Act, 1974 and its associate orders such as Order 1987 and the Environmental Impact Assessment Guideline for Dam and/or Reservoir Project, 1995, the ecological input is unfortunately still being marginalised in the making of sound EIA.

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