Using Text Mining to Evaluate the Integrative and Adaptive Elements of Water Resource Institutions for Songkhla Lake Basin, Thailand

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***Abstract*-The study was based on the use of text mining to evaluate the integrative and adaptive elements of water resources for related and relevant institutions in the Songkhla Lake Basin, Thailand. The results were able to show some very interesting patterns like being able to determine the basic statistics of the sets of institutions under review including the degree of fragmentation and gaps, institutional priorities and their capacity to support the element of integrative and adaptive resource management. The major outcome of this work is its ability to prove that the quality of the legal operating documents for state natural resource governance can be quantitatively analysed using the tool and the application of appropriate equations to determine the inherent policy weaknesses, degree of actors vested interests as well as determine the measures of their suitability for enhancement of resources governance.**

Keywords- adaptive, integrative, lake basin, governance, management, institutions

I. INTRODUCTION

Lake basin institutions globally are beset with inadequacies because most times they are not designed for the specific governance of lakes and their basins. These institutions are often derived from countries' general water resources or even national resources institutions, which minimally address the complex combination of the lentic and lotic characters of lakes. Studies have shown that the lentic characteristic of lakes, that is, their integrating nature, long retention time, and complex response dynamic is what set them apart from other water sources (ILEC, 2011) [48].

The biggest challenge is the inflexibility and rigidity of current institutional regimes for such complex and dynamic systems like the lake basins, which has resulted in slow management response to lake basin stressors, allowing the basin to be corrupted. According to Lazarus (2004) [78], the inflexibility of current environmental and natural resources laws make resilience management difficult due to slow response to new information caused by organizational bureaucracy as well as the conservative and resistant nature of these institutions. This hinders the institutional capacity to capture and manage the synergistic linkages of the lake basin systems, thereby putting constraints on sustainable governance (Garmestani et al. 2009) [35]. This is critical because environmental governance can only succeed if institutions evolve and fit with the ecosystems they are designed to govern (Dietz et al. 2003, Garmestani and Benson, 2013) [18, 34].

Institutions in this paper refer to the body of rules, decision making procedures and programmes that give rise to social practices, assign roles to the participants in these practices and guide interactions among occupants of the relevant roles (IDGEC 1999, Ostrom 1990) [47,91]. They can be laws (Acts of Parliaments), regulations, standards, judiciary pronouncements, policies, directives, management procedures and such likes. They provide the stability and predictability required to maintain the collective existence of society (Scharpf 1997, Gupta, et al. 2010) [99, 39]. However, the fact still remaining that institutions are drafted, designed and implemented by actors (North 1990, Kalikoski et al. 2002) [85, 53] with vested interests and varied influences, which undermine the institutional capacity to be integrative and adaptive. Actors generally design institutions around the resources they exploit (North 1990, Kalikoski et al. 2002) [85, 53] to suit their vested interests, using ambiguities to couch real intentions without considering the complex and dynamic conditions of the ecosystem. This has often led to disastrous circumstances, which explains the state of most of the world's lakes.

To make it workable, most of the current institutional regime used to govern and manage lake basins are obsolete and outmoded, no longer fir for the governance of the natural resource they oversee. Hoffman and Zellmer (2013) [44] noted that resource management institutions in the United States and indeed the world over, have become 'prisoners of history' holding on to past rather than present, much less future, knowledge and necessity (Dovers and Hezri 2010) [20]. These institutions were designed to manage water resources based on past conditions, which greatly differs from current conditions, and so are ill-equipped to address today's challenges, especially with the challenges of global climate change (Hoffman and Zellmer 2013) [44]. Laws which seemed sensible in a time when resources were thought to be inexhaustible are now outmoded (Cortner and Moote 1994) [13] because the institutions that served us well in the past have outlived their intended purpose and, sometimes their usefulness (Wilkinson 1992) [118]; thus hindering their capacity to capture the current issues of resource governance and management. This is even tougher on lake basins because none of these institutions ever captured the peculiar idiosyncrasies of the lake basin, even in their outmoded state.

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It, therefore, becomes expedient that lake basin institutions be designed to capture the complex and dynamic nature of lakes and essentially be adaptive and integrative in order to ensure flexibility and resilience as opposed to the current rigidity. Considering that institutions have been identified as significant barriers to sustainable natural resource governance (Cortner et al. 1998) [12], lake basin institutions must be designed and implemented to ensure sustainable governance. Lake basin institutions need to include adaptive and integrative elements because they will ensure that institutions relate to the specific nature of the lakes as well as be flexible enough to assimilate future changes and deal with uncertainties, like unexpected challenges. The adaptive elements enhance the ability of resource management systems to be robust and resilient as well as the capacity to handle all uncertainties that may arise with the lake basin system. The integrative elements, on the other hand, strengthens and enables the governance systems to promote better coordination between all actors and organizations involved in the lake basin and its externalities (Rouillard, et al. 2013) [98].

There already seems to be a shift from the traditional command and control, and top down institutional systems for water resources management to a more integrated and adaptive resource governance designed to reduce challenges of institutions as well as enhance management decisions under uncertainties (Engle et al. 2011, Jønch-Clausen and Fugl 2001) [23,51]. Recognizing that we cannot reliably protect a natural resource legacy without a strong and substantive mandate (Flournoy and Driesen 2010) [30], clarifies the United State National Research Council (2001) [115] declaration that 'the research agenda for the 21st century should give priority to developing new legal arrangements governing diversions and consumptive use that emphasize flexibility and facilitate the management of water scarcity' (US NRC 2001) [115].

However, the inevitable and vital question becomes, 'how do we develop such institutional frameworks?' We argue that the first step is not to jump into conclusions for changing the institutions, but rather to first review the current institutions to measure the adaptive and integrative elements they contain. Traditionally, institutional analysis have been done qualitatively (Young, 2002) [122], but Ekstrom and Young (2009) and Ekstrom et al (2009) [27, 28] have proved that institutional analysis can also be done quantitatively. We, therefore, believe that quantitative analysis of institutions can give credence to the results of qualitative analysis. This is why we argue that a quantitative institutional analysis to assess adaptive and integrative readiness is of essence in this context because it can show in numbers and graphical illustrations a guide picture of the current state of the institutional framework under review. To this effect, this work expands on the research of Ekstrom and Young (2009) [27] and Ekstrom et al (2009) [28] by using text mining to evaluate the integrative and adaptive elements of the related and relevant institutions for the Songkhla Lake Basin (SLB), Thailand.

II. THE PHYSICAL AND INSTITUTIONAL CONTEXT OF SONGKHLA LAKE BASIN (SLB) WATER RESOURCES MANAGEMENT

In the SLB, surface and groundwater resources are hydrologically connected, but the institutions devised to govern the resources are different. These differences exist in both the laws and the agencies of government charged with the responsibilities of managing them. In this section, we present the resources and their management systems.

A. Water Resources

SLB is a basin rich in both surface and groundwater resources. Songkhla Lake is the main surface water resource in the Basin and is the largest lake in Thailand. The Lake and its Basin lies in three provinces of Southern Thailand, namely Phattalung, Songkhla and Nakhon Si Thammarat, made up of 12 sub-basins and is 1.5 - 2 meters deep (ONEP 2011) [88].. The Lake covers an area of approximately 1,042 km^2 and consists of four interconnected lake ecosystems: Thale Noi (approximately 27 km^2), Thale Luang (approximately 473 km^2), Thale Sap (approximately 360 km^2), and Thale Sap Songkhla (approximately 182 km^2) (Ratanachai and Sutiwipakorn 2005) (Fig. 1).

The estimated mean total surface runoff from several hundreds of smaller rivers and streams in the Basin is 5,500 million m^3, which can drop to 2,000 million m^3 in dry seasons. The total volume is stored in the Songkhla Lake at a mean sea level of 1,600 million m^3, increases to 3,800 million m^3 when the lake level reaches 1.5 m MSL (Taylor & Sons 1985) [104].. Water levels in the system fluctuate each year both in response to seasonal variations in sea level and rainfall, maximum during northeast monsoon in December (+0.27 m MSL) and minimum in August (-0.35 m MSL) (Emsong 1997) [21]. The system exhibits a mixing path of freshwater up-stream and salt down-stream, via complicated topography. Narrow channels connect Thale Sap and Thale Sap Songkhla, which restricts attenuates tidal oscillation from a range of 250-600 mm (neap/spring) at the sea entrance to only 30-40 mm at the northern part of Thale Sap. Some amounts of irrigation water are pumped from the Thale Luang at the Ranod pumping station to feed the rice fields and the amount varies depending on the salinity level. The three major potential sources of groundwater resources are: shallow sand aquifers, deep gravel aquifers, rock aquifers and meta sediment aquifers in the SLB (NESDB and ONEB 1985, RFD 1994). Groundwater extraction from Hat Yai basin alone is estimated at approximately 35 million cubic meters per year or approximately 96,000 cubic meters per day of groundwater (Ratanachai and Sutiwipakorn, 2006) [96].

The three basic water resources problems confronting Songkhla Lake Basin are: dry season's allocations, groundwater depletion and deterioration of water quality. According to Loucks and Van Beek, (2005) [80], these are issues of too little water (scarcity), too much water (damage due to flooding), and polluted water (water quality), which also include issues like degradation of aquatic and riparian ecosystem. The root causes of these problems are the management approach, which treats

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water as an open access resource and the impact of indiscriminate discharge of wastewater into the environment. Other problems include the lack of sound water resources allocation principles, the existence of too many water agencies marked by overlapping mandates, vested interests and acute battles for supremacy, uneven water infrastructures and tendency to focus on increasing supply without attention to improving the demand side inefficiencies (Christensen and Boon-long, 1994).[8]

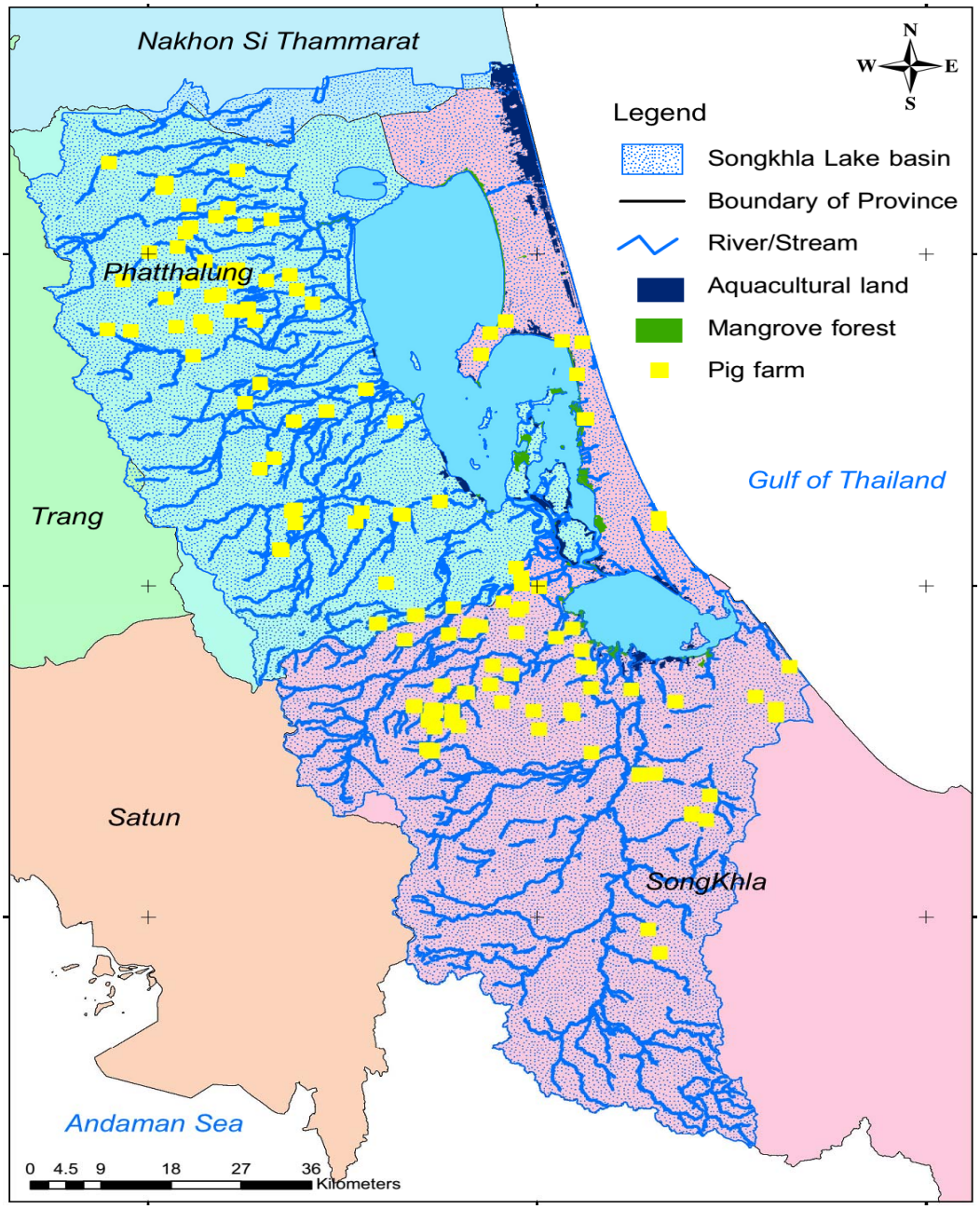


Fig. 1 Map of Songkhla Lake Basin

Source: Peter Cookey

Several studies have confirmed serious water quality deterioration, which has affected the productivity of the lake. Pornpinatepong (2010) [94] noted that changes are mainly due to human activity such as water pollution from households and industries, and deforestation of the catchment area. The source of industrial water pollution originates mainly from rubber and food industries. The source of agricultural pollution are from the shrimp farms, pig farms, crop farms and rubber plantations, which release wastewater with a high content of fertilizers, pesticides and other toxic compounds. The other sources of these contaminants are the human communities around the lake. TSPR (2010) [110] indicated that the Songkhla lake water quality deteriorated due to relatively high BOD. This Lake is one example of a tropical shallow lake facing critical water quality deterioration and loss of fish population (Chesoh and Lim, 2008) [6]. DEQP (2008) [16] declared Songkhla Lake among the poor quality-highly polluted river systems in Thailand in 2003 (class 5 – very poor).

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B. The Institutional Framework

The study identified 19 sets of Thailand's national laws that were relevant and related to water governance in the SLB. These laws can be summarized under the following themes: marine, environment, fishery, irrigation, forestry/land and local administrative laws. The general characteristics of these laws are the fact that they are fraught with fragmentation and overlapping responsibilities and filled with a lot of gaps (Cookey, et al. 2015a/b) [10,11]. The institutional framework for the implementation of the Integrated Water Resources Management (IWRM) can be found in the 2002 Water Resources Regulation, which makes provisions for water resources to be managed using the river basin as a territorial and administrative unit with a committee as a management organization, [resulting in the establishment of the Songkhla Lake Basin Committee (SLBC) as one of the 25 river basin committees (RBCs)], administered by the Department of Water Resources (DWR) of the Ministry of Natural Resource and Environment (MONRE) (DWR 2005). The older SLB committee is the Songkhla Lake Basin Development Committee (SLBDC) and was established in 1993 as an inter-agency coordinating body by the Office of Natural Resources and Environmental Policy and Planning (ONEP) (Uraiwong, 2013) [89].

Technically, the direct management and governance of water and other natural resources in the SLB are the responsibilities of the 6 most dominant ministries and their centralized deconcentrated departments through their provincial/regional offices and the various Local Administrative Organizations (LAOs) supervised by the provincial governors. These ministries include: Ministry of Agriculture and Cooperatives (MOAC), the Ministry of Natural Resources and Environment (MONRE), Ministry of Industry (MI), Ministry of Interior (MOI), Ministry of Transport (MOT) and Ministry of Public Health. In specific terms, water resources development, management, allocations and quality control activities are undertaken by the Department of Water Resources (DWR), Royal Irrigation Department (RID), Groundwater Resources Department (GRD) and Pollution Control Department (PDC) regional offices located in the SLB.

The DWR is the main state agency responsible for coordinating surface water resources planning, development, conservation and protection in the SLB and they do this through their regional offices. The RID is responsible for the allocation of water to farmers for agricultural purposes through various irrigation schemes. The Department of Groundwater Resources (DGW) regional office in the Basin oversees the development and management of groundwater resources. (Bamroongrugsa, 1998, Kongthong and Ratanachai, 2012, ONEP 1997, 2005, 2008, 2011) [2, 77, 90, 88]. The Provincial Waterworks Authority (PWA) is responsible for the development and management of municipal urban water supply facilities in the Basin. Water supply schemes in smaller cities are operated, maintained and managed by the respective Municipality Administrative Organizations (tessaban), village waterworks are managed by the Tambon Administrative Organizations (TAO) and wastewater and sanitation responsibilities are under the local government administrations (LAOs) (KOT, 1991, Nagari et al. 2008) [58, 83].

There are also, active civil society organizations involved in the development activities in the Basin. One of the major actors are the Water Users Association, which partner with RID on issues of irrigation. They play a key role in negotiating water allocation for its stakeholders according to farmers' planting schedules and help in settling water allocation disputes and irrigation canal maintenance and dredging (Kongthong and Ratanachai, 2012) [77].. There are also numerous cooperatives and thrifts societies, mangrove protection groups, weaving and environmental protection and conservations of elephant groups actively involved in the conservation and protection activities of the SLB.

III. METHODOLOGICAL APPROACHES

A. Conceptual Framework of Adaptive Integrated Lake Basin Management (AILBM)

This conceptual framework is a combination of organizational management (adaptive) and governance (integrated) frameworks to develop an Adaptive Integrated Lake Basin Management (AILBM) which is analytical, diagnostic and prescriptive in nature and designed for the sustainable governance and wise use of the basin resources. We designed this hybrid concept based on the need to strengthen concurrently the enabling environment, institutional roles and functions of various administrative levels and stakeholders, and management instruments, including effective regulation, monitoring and enforcement. The Adaptive Integrated Lake Basin Management (AILBM) is derived from three concepts: Integrated Water Resources Management (IWRM) (Medema et al. 2008, odendaal 2002, Wallace et al. 2003, Jonker 2002) [81, 86,116, 52]; the Adaptive Management (AM) (Walters and Hiborn 1978 Gundrson et al. 1995, Hebron 2003) [117, 38, 41]; and the Integrated Lake Basin Management (ILBM) (ILEC 2007, ILEC 2005, 2011, RCSE and ILEC. 2014) (Fig. 2).[49, 50, 97].

AILBM is an approach of lake basin governance that is designed to be gradual, continuous, holistic, systemic and integrative in nature with the capability of ensuring resilience, flexibility, adaptability, active participation of all stakeholders, equipped with effective and efficient decentralized systems and adequate feedback mechanisms that address the resource management system as well as the water resources quality and quantity for the overall achievement of sustainable governance and wise use of basin resources (Cookey, et al. 2015a) [10].

In other words, the institutions that govern lake basins should capture the synergistic-linkages between the sector, actors, stressors and management to achieve an institutional fit for lake basins. The overriding aim of the AILBM is the achievement of a fit-for-purpose governance system for lake basins (Garmestani and Allen, 2014) [33]. (Table 1).

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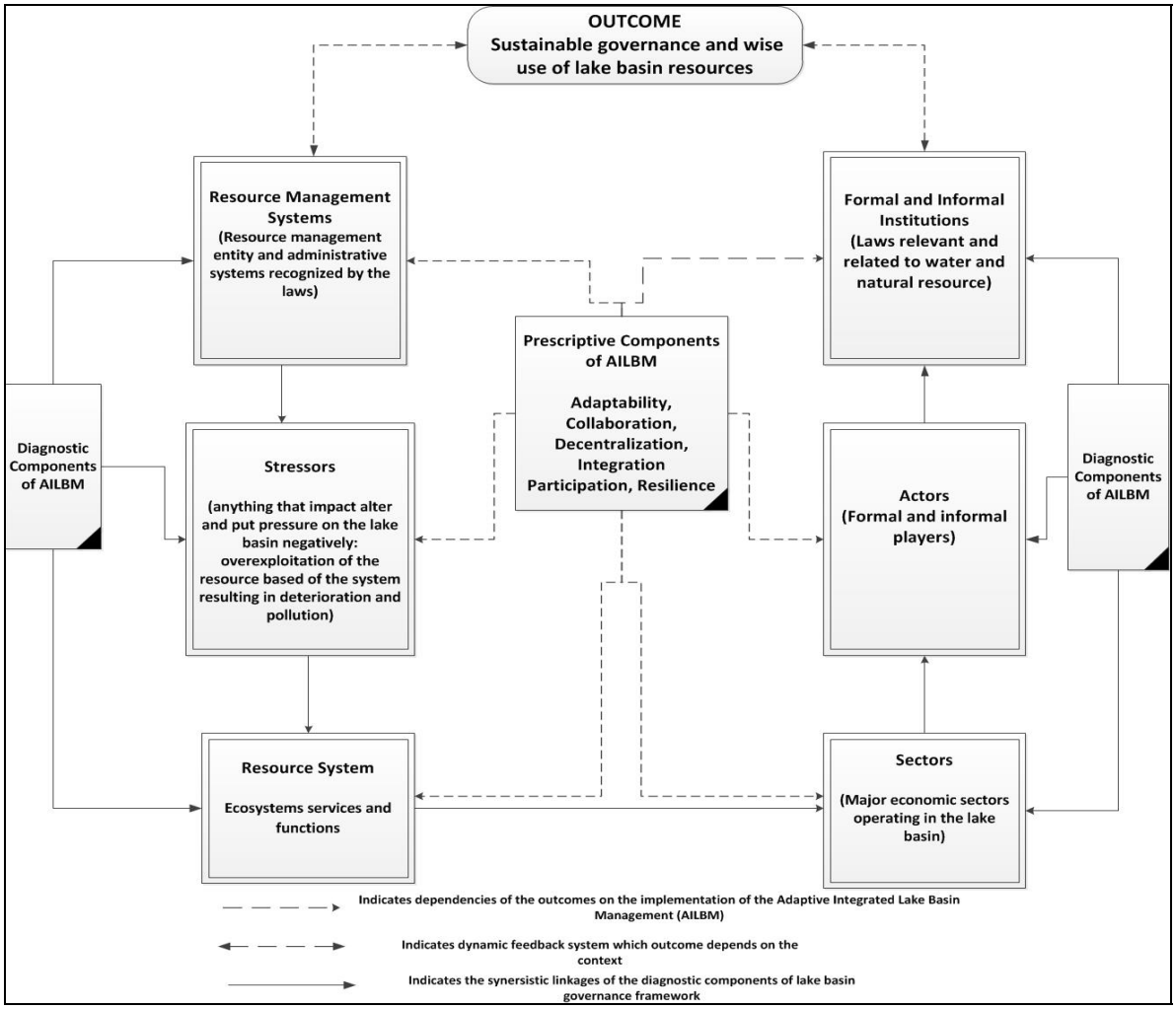


Fig. 2 Adaptive and Integrated Lake Basin Management (AILBM): A Diagnostic and Prescriptive Conceptual Framework for lake basin management and governance. Source: Cookey, et al. 2015a/b [10, 11].

TABLE 1 ELEMENTS OF ADAPTIVE INTEGRATED LAKE BASIN MANAGEMENT (AILBM) FRAMEWORK

Elements	Interpretation
Diagnostics Components of AILBM	
Sector	Major social and economic activities in the lake basin, which may affect the quality and quantity of water and other natural resources in the basin
Stressors	Constitute major agents and sources of nuisance and impact negatively on the lake basins resources
Actors	Key players or stakeholders involved in the designing of the governance system as well as those involved in the usage. The actors create or exacerbate many of the current lake basin challenges
Resource systems	Ecosystems services and functions of the lake basin which includes the exploitation and utilization of the basin resources
Resource management systems	The core of the lake basin administration. It includes the entity of the resources management, administration and technology for pollution control and funding mechanisms for resource management in the basin
Institutions	Fundamental tools for resource management and reflect the way people interact with one another and the environment.
Prescriptive Components of AILBM	
Adaptability	Focus on the role of human actors in the lake basin to mainstream resilience in the management of lake basin to achieve institutional fit
Collaboration	Designed to encourage social actors in the lake basin to work together to enhance the capacity of the socio-ecological systems to cope with intermittent shocks
Resilience	Deals with the ability of the lake basin to absorb disturbance and still maintain the functioning of the ecosystem
Decentralization	Deals with the issue that the lake basin requires an organization, committees, agencies or authorities of some sort to manage them at the lowest level of government.
Integration	Synergistic interaction among agencies involved in lake basin management and related policies fields and also the capacities of the actors to coordinate their activities between government agencies and with other stakeholders

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Participation	The process of stakeholders to influence and share control over the development initiatives and the decision and resource, which affect them in the lake basin

Source: Cookey, et al. 2015a

B. Text Mining Procedure for Assessment of the Integrative and Adaptive Capacity of SLB Institutions

To quantitatively determine the degree of integrative and adaptive capacity of the institutions of governance of SLB the text mining tool was used to extract useful information from data sources through the identification and exploration of interesting patterns (Berelson, 1952) [3]. This approach focused on the collection of 19 sets of laws relevant and related to water and natural resources governance in the SLB (Table 2).

TABLE 2 THE 19 SETS OF LAWS IN THAILAND RELEVANT AND RELATED TO WATER RESOURCES IN THE SLB

Category	**Related water resources institutions in the SLB**
Fishery Laws	Right to Fish in Thai Fishery Waters Act (FTW)
	Fisheries Act (FA)
Irrigation Laws	People Irrigation Act (PI)
	State Irrigation Act (SI)
	Field Dykes and Ditches Act (FDD)
Marine Laws	Navigation in Thai Waters Act (NTW)
	Marine Salvage Act (MS)
	Merchant Marine Promotion Act (MMP)
Environment Laws	The Enhancement and Conservation of National Environmental Quality Act (ECNE)
	Public Health Act (PH)
	Hazardous Substance Act (HS)
	Factory Act (FAC)
Forestry/Land Laws	Commercial Forest Plantation Act (CFP)
	National Reserved Forest Act (NR)
	Wild Animal Reservation and Protection Act (WAR)
	National Park Act (NP)
	Land Development Act (NP)
Local Administrative Laws	Plans and Process of Decentralization to Local Government Organization Act (PPD)
	Tambon Council and Tambon Administrative Authority Act (TA)

The process involved the collection and conversion of the electronic copies of these laws into readable form by Windows Excel. Then, select representative terms with integrative and adaptive attributes were taken from the AILBM conceptual framework to develop a query language. The institutions were mined for these terms, and data visualized using the Windows Excel software statistical package. This resulted in the development of a Term-Document-Matrix (TDM), which is a systematic table that organizes topics according to their frequency of occurrence in each of the documents analysed (Feldman and Sanger 2007, Cookey, et al. 2015b) [29, 11].

Document Agency Matrix (DAM) was also developed by physically reading through the SLB relevant and related water laws to discover agencies with relevant statutory mandates. Where a set of institutions identified an organization responsible for the implementation of the laws (table 3); one (1) point was awarded; where an organization was nominated into a committee under that law, an half point (0.5) was awarded and zero was awarded to none assignment of any responsibilities for the law under review (Ekstrom and Young 2009, Cookey, et al. 2015b) [27, 11].

Verification of the text mining process was carried out using stakeholders structured livelihoods, perceptions and resources governance surveys, with simple random sampling technique (Teddlie and Tashakkori, 2009) [108], and semi-structured face-to-face in-depth interviews with key professional informants as well as reviews of relevant literature on governance of lake basins (Fig. 3).

1) Statistics of Resource Governance Institutions

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The basic statistics of the selected water institutions under review was also be determined using the detailed descriptive statistics of the text mining analysis presented in the Term Document Matrix (TDM) and Document Agency Matrix (DAM). It also shows the period these laws were enacted.

TABLE 3 CENTRAL GOVERNMENT ORGANIZATIONS RESPONSIBLE FOR THE IMPLEMENTATION OF THE WATER AND NATURAL RESOURCES RELATED AND RELEVANT LAWS IN THE SLB

Centralized Ministries
Ministry of Natural Resources and the Environment (MONRE)
Ministry of Agriculture and Cooperatives (MOAC)
Ministry of Interior (MOI)
Ministry of Industry (MI)
Ministry of Transportation (MOT)
Centralized Deconcentrated Departments
Department of Water Resources (DWR)
Department of Groundwater Resources (DGW)
Pollution Control Department (PCD)
Office of Natural Resources and Environmental Policy and Planning (ONEP)
Royal Forest Department (RFD)
Department of National Park, Wildlife and Plant Conservation (DNWP)
Royal Irrigation Department (RID)
Department of Fisheries (DOF)
Department of Provincial Administration (DOPA)
Department of Local Administration (DLA)
Department of Disaster Prevention and Mitigation (DDPM)
Local Administrative Organization (LOA)

2) Overlap Analysis (index of the Degree of Fragmentation)

Overlap is one of the leading causes of fragmentation and occurs when two or more agencies have the same jurisdiction or influence over the same area, activity, and/or resource (Ekstrom and Young 2009) [27] and manifests as duplication or gaps in authority (Hill et al. 2008) [43]. Overlap was determined by dividing the number of laws a particular agency appears in the Document Agency Matrix (DAM) over the total number of agencies in the laws reviewed and multiplied by one hundred. It was also be used to show the degree of involvement and the overriding influence of central government ministries and their deconcentrated departments in the governance and management of the SLB.

$$D\ (IF, WLsSLB) = \frac{\#A\ WLs\ SLB}{\sum(A\ WLs\ SLB)} x\ 100 \quad (1)$$

Where: AD = Agency Density, Ls = Laws (Acts of Parliament), A = Agencies that appear in WLsSLB, WLsSLB = Water Laws relevant to SLB, SLB = Songkhla Lake Basin.

3) Gaps Analysis (Index of the Degree of Misfit/Mismatch)

Gap is when a critical linkage between two components of a system (topic) is not addressed in the institutions (laws) (Ekstrom and Young 2009) [27]. The linkages refer to interactions across sectors, stressors, resource systems, resource management systems and our proposed Adaptive Integrated Lake Basin Management (AILBM). The modelled linkages that score zero in each law matrix are a gap. Gaps are a measure of institutional mismatch or misfit. It was calculated by dividing the number of the missing-links of a representative term in the laws reviewed over the sum total of all the missing-links of the representative terms (TDM) multiplied by one hundred.

$$G(WLsSLB) = \frac{\#\ gaps}{\#\ linkages} x\ 100 \quad (2)$$

Where: G = represents the proportion of the legal gaps to modeled links (gaps = number of modeled links absent from the laws; linkages = number of total modeled links in the system); WLsSLB = Water Laws relevant to SLB; SLB = Songkhla Lake Basin.

4) General Institutional Priority

Several studies have submitted that the crisis of the SLB is the over-reliance on resource utilization of the laws negating wise use and conservation. To determine the institutional priorities of the SLB water related laws we divided the representative terms on topics (Tc) (sectors, stressors, resource system and resource management system) over the sum total of topics by issues category and multiplied by one hundred.

$$IP\ (WLsSLB) = \frac{(T.WLsSLB\ Tc)}{\sum(T.WLsSLB\ T_c)} x\ 100 \quad (3)$$

Where: IP = Institutional Priority; T = Term; WLsSLB = Water Laws relevant to SLB; Tc = Topic; SLB = Songkhla Lake Basin.

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5) Institutional Capacity to Support Integrative and Adaptive Resource Management

To fully understand the capacity of existing institutions to support integrative and adaptive resource management, we attempted to determine and measure quantitatively the degree of response of the existing institutions to the conventional resource management and the AILBM conceptual representative terms from the DTM. The purpose of this indicator is to use text analysis to determine the institutional response to management of the resource base.

$$IRRM\ (WLsLB) = \frac{(T,WLsLB\ RM\ \&\ AILBM)}{\sum (T,WLsLB\ RM\ \&\ AILBM)} \times 100 \quad (4)$$

Where: IRRM = Institutional Response to Resource Management; T = Term; WLsLB: Water Laws relevant to LB; RM = Resource Management; AILBM = Adaptive Integrated Lake Basin Management; LB: Lake Basin.

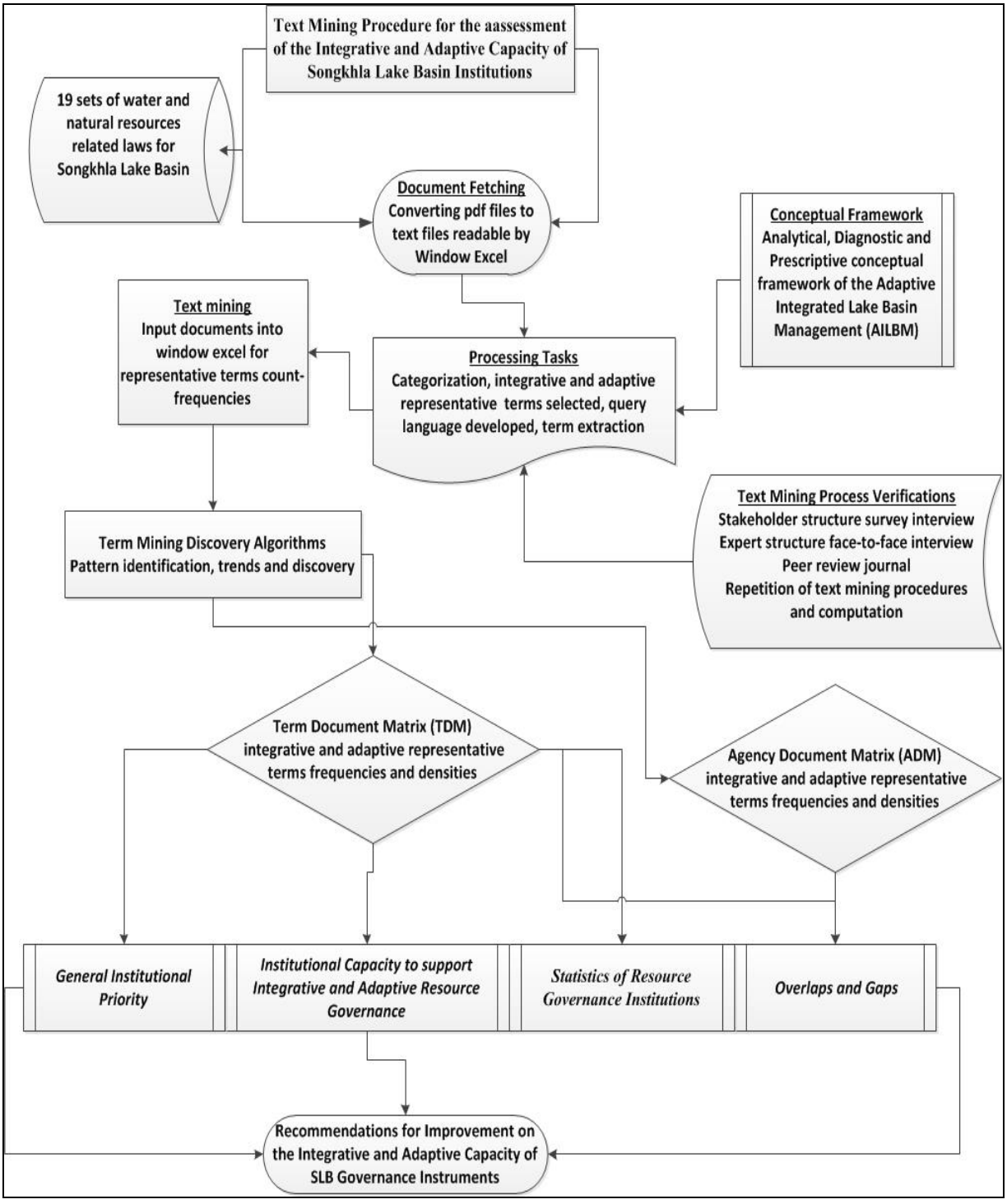


Fig. 3 Simple concept flow chart representation of text mining for the aassessment of the Integrative and Adaptive Capacity of Songkhla Lake Basin Institutions

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C. Data Analysis

Data analysis was triangulated by examining, categorizing, tabulating, testing or otherwise combining both the qualitative and quantitative evidence to critically analyze the integrative and adaptive capacity of governance instruments of the SLB. The text mining analysis employed the tool of Microsoft Excel Software for term-count-frequencies using the Document Agency Matrix (DAM) (Table 3) and the Term-Document-Matrix (TDM) (Table 4). The results of the text mining were subjected to computations of institutional variables and data were visualized and presented in tables, line graphs and histograms.

TABLE 4 SUMMARY OF DOCUMENT AGENCY MATRIX GENERATED FROM TEXT MINING ANALYSIS USED FOR THE DETERMINATION OF INSTITUTIONAL PARAMETERS IN THE SLB

Agencies	Fishery Laws	Irrigation Laws	Marine Laws	Environment Laws	Forestry/Land Laws	Local Administrative Laws	Total
MONRE	0	0	0	2.5	2	0	4.5
MOAC	2	3	0	1.5	4	0	10.5
MOI	0	0	0	1	0	2	3
MI	0	0	0.5	3.5	1	0	5
MOT	0	0	2	1	o.5	0	3
MPH	0	0	0	2	0	0.5	2.5
DWR	0	0	0	0	0	0	0
DGW	0	0	0	1	0	0	1
PCD	0	0	0	1	0.5	0	1.5
ONEP	0	0	0	1	0	0	1
RFD	0	0	0	1	4	0	5
DNWP	0	0	0	1	1	0	2
DMCR	0	0	0	0	0	0	0
RID	0	3	0	0.5	0.5	0	4
DOF	2	0	0	0	0	0	0
DOPA	0	0	0	0.5	0	1	1.5
DLA	0	0	0.5	1	0	1	2.5
DDPM	0	0	0	0	0	0	0
LAO	2	3	0	2	2	2	11
Total	6	9	3	20.5	15	6.5	58

* For interpretation of abbreviation see table 2

IV. RESULTS AND DISCUSSION

A. Statistics and Date of Enactment of SLB Water Related Institutions

The 19 sets of institutions (laws) used in this study contained 1263 sections, 554,740 characters and 128,482 words. The P-Value (0.62) indicates a strong evidence for the assumption that text mining is a useful tool in the evaluation of the degree to which elements of integrative and adaptive are embedded in the institutions of water resources related and relevant to the SLB. Thus, the statistical significance showed that indeed text mining can be useful in the assessment of institutions of water governance for lake basin. Also, the study showed that the core water laws were enacted between the period of 1913 and 1964; the environment related laws were created in 1992, the decentralization laws were promulgated between the period of 1994 and 1999 indicating that most of the laws related and relevant to water resources governance in the SLB were obsolete and outmoded (Fig. 4).

This result is in agreement with Sukhsri, (1999) [103] who observed that, legislation controlling the development and use of natural resources, such as land, forestry and minerals, were enacted many decades ago and that the most important natural resources of all, i.e. water, is not completely covered by any specific national act or statute. Also, other scholars on Thai's water and natural resources institutions have described these laws as been very old, outmoded and obsolete and may be based on conditions that no longer exist (Wongbandit 2005, Biltonen et al. 2001, Biltonen 2011) [119,4, 5] leading to ambiguities, lacunae, inconsistencies, and even outdated rules (Peczenik 1995) [93]. Therefore, these obsolete institutions will definitely lack the required integrative and adaptive elements that would enhance adequate resource governance.

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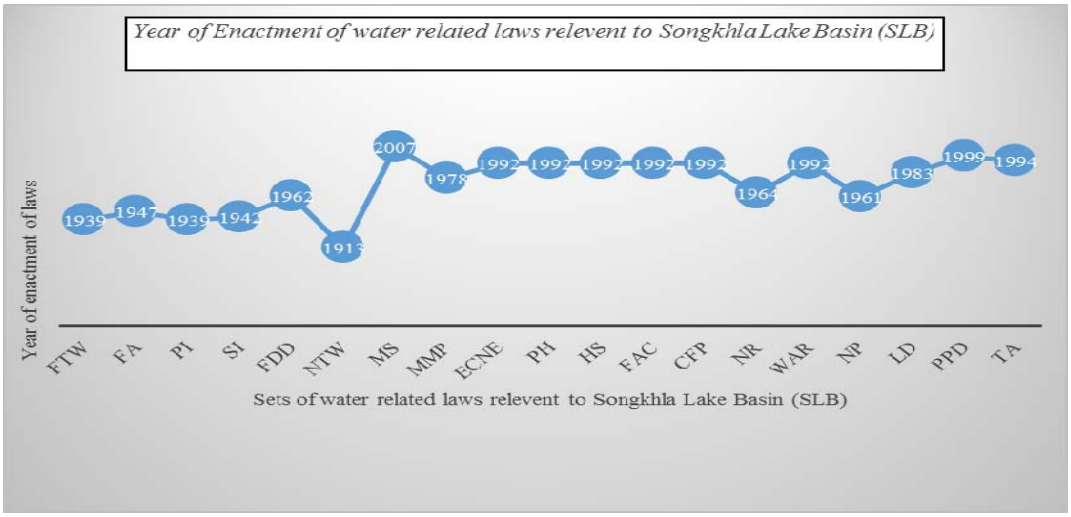


Fig. 4 Years of enactment of 19 sets of SLB water related laws computed from text mining analysis (for interpretation of abbreviations see Table 2)

B. Overlap - the Degree of Fragmentation

The results indicated that there were serious institutional fragmentation and gaps (mismatch) within the 6 main centralized ministries and the 13 deconcentrated departments involved in the governance of water resources of the SLB. Also, the results revealed that water overlapped (fragmentation) throughout the 19 laws reviewed and all the 19 agencies have mandates covering some aspects of water issues and no laws addressed the issues of water resources comprehensively. This shows a high fragmentation of water issues in the relevant laws and agencies, indicating duplication of responsibilities, which may lead to conflicts in the Basin (Fig. 5).

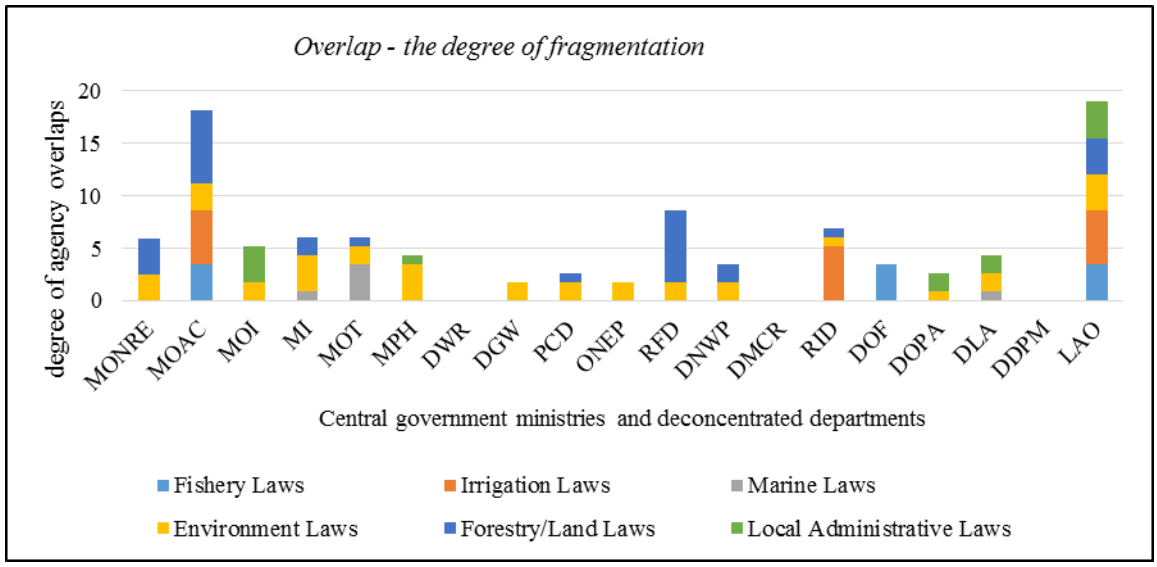


Fig. 5 Central ministries and deconcentrated departments overlap in the SLB computed from text mining analysis (for interpretation of abbreviations see Table 3)

The ministries with the highest degree of overlaps are MOAC and MOI with their deconcentrated departments. In the 19 sets of laws under review, these ministries and her agencies have one form of related responsibilities or the other. Institutional fragmentation challenge is manifested with duplication, overlap, or gaps in authority and of responsibilities among multiple actors and/or agencies jurisdictions and duplication between levels of government (Hill et al 2008) [43]. With more than 4 centralized ministries and 15 deconcentrated departments with fragmented responsibilities in the management of quantity and quality of ground and surface water resources in the SLB, the absence of integrated and adaptive management of the water resources in the Basin is clearly evident.

These findings are in agreement with Christensen and Boon-Long, (1994), Sukhsri (1999), Neef (2008), Kanjina (2008) [8, 103, 84, 54], who observed that the Thai water sector is heavily characterized by institutional and jurisdictional fragmentation with poor sectoral integration and coordination and a strong adherence to command-and-control approaches. The difficulty of moving toward a more integrative and adaptive water governance is perhaps best captured by Thomas and WAC (2005) [112], when they observed that despite over thirty years of conscious efforts to adjust policies, organizational structures, regulations,

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programs and budgets to facilitate cross ministerial coordination, relatively little progress is apparent at the central government level. Indeed, even cross departmental coordination, within individual ministries, is a ridiculously haunting challenge.

TABLE 5 SUMMARY OF TERM-DOCUMENT-MATRIX (TDM) GENERATED FROM TEXT MINING ANALYSIS USE FOR THE DETERMINATION OF INSTITUTIONAL PARAMETERS IN THE SLB

Topics	Terms	6 major sub-divisions of the 19 sets of institutions relevant and related to water						Terms Total Frequency	Terms Absence links (Gaps)
		Fisheries Laws	Irrigation	Marine Laws	Environmental Laws	Forestry/Land Laws	Local Admin Laws		
Sectors	Tourism	0	0	0	1	2	3	6	14
	Agriculture	292	14	1	10	17	2	336	5
	Industry	14	1	3	23	1	1	43	10
Stressors	Eutrophication	0	0	0	1	0	0	1	18
	Hazardous	0	0	0	185	0	0	185	17
	Pollution	0	0	0	10	0	0	10	18
	Sewage	0	0	0	13	0	0	13	18
	Wastewater	10	0	0	89	0	2	101	16
	Solid waste	0	0	0	13	0	2	15	15
	Deforestation	0	0	0	0	0	0	0	19
	Siltation	0	0	0	0	0	0	0	19
	Erosion and	0	9	0	0	0	0	9	17
	Recreation	37	0	0	0	0	2	39	16
	Consumption	9	2	0	2	0	2	15	15
	Cultivation	78	24	0	0	0	0	102	15
Resource Systems	Fish	1104	2	2	1	15	1	1125	12
	Shrimps	67	0	0	0	0	0	67	18
	Crabs	19	0	0	0	0	0	19	18
	Forest	1	0	0	0	188	0	189	13
	Water	106	167	18	23	20	15	349	3
	Wildlife	0	0	0	2	4	0	6	16
Resource Management Systems	Conservation	10	2	0	44	12	0	68	13
	Protection	4	1	2	15	11	0	33	10
	Public Health	0	0	0	45	0	2	47	15
	Water Quality	0	0	0	3	0	0	3	17
	Management	4	0	0	32	1	7	44	14
	Prevention	0	1	8	26	1	2	38	9
	Sanitation	0	0	0	1	0	1	2	17
	Mitigation	0	0	0	3	0	0	3	18
	Coordination	0	0	4	0	0	0	4	18
AILBM	Adaptability	0	0	0	0	0	0	0	19
	Collaboration	0	0	0	0	0	0	0	19
	Resilience	0	0	0	0	0	0	0	19
	Decentralization	0	0	0	0	0	27	27	18
	Integration	0	0	0	2	0	0	2	18
	Participation	0	0	0	0	0	3	3	17
	Total	1762	223	38	547	272	72	2910	553

Note:

* AILBM – Adaptive Integrated Lake Basin Management

* Topics – are the core issues of concern in lake basin management and governance extracted from the AILBM

* Terms – are relevant words, concepts, and issues extracted from the 'Topics' because the 'Topics' were two broad and ambiguous

* Institution – is the 'Topic' that was mined for represented by relevant and related laws

Indeed, the challenge of integration in water resources management is fragmentation which Cook (2014) [9] described as 'wicked problems' and argues that excessive fragmentation could be problematic and has the potential to limit integrated planning and management in the Basin, which goes beyond individual departments boundaries (Ostrom 1990) [91]. Simachaya and Yolthantham (2006) [102] also, argue that in Thailand, there is no integrated water resources management approach because water management is separated between the quantity and quality due to agency responsibilities and their respective regulations. However, Hoffman (2013) [44] observed that the efforts of moving towards integrated management planning can strengthen accountability and enforceability in water resources.

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C. 4.3 Gaps - the degree of misfit/mismatch

There were high rates of institutional gaps recorded in the study (Fig. 6). There was a total of 592 gaps (absence links). The largest gaps was (n=19, 3.44%) and these terms were not found in all the 19 sets of laws that were text mined. These terms were 'adaptability', 'collaboration' and 'resilience'. These were closely followed by 'decentralization', 'integration', 'coordination' and 'mitigation' with (n=18, 3.26%) gaps and 'participation' recorded a total of (n=17, 3.08%) gaps. These were representative terms used for text mining for evaluation of the degree of the integrative and adaptive capacity of the institutions of water governance in the SLB. Even the text mining for the indicative terms for the conventional resource management system also recorded high number of gaps. The only indicative terms with low degree of gaps was 'water' and 'agriculture', and these were the most fragmented issues in the SLB. The implication of this result is that the SLB institutions are not fit-for-purpose to address the challenges of weak integration and adaptation.

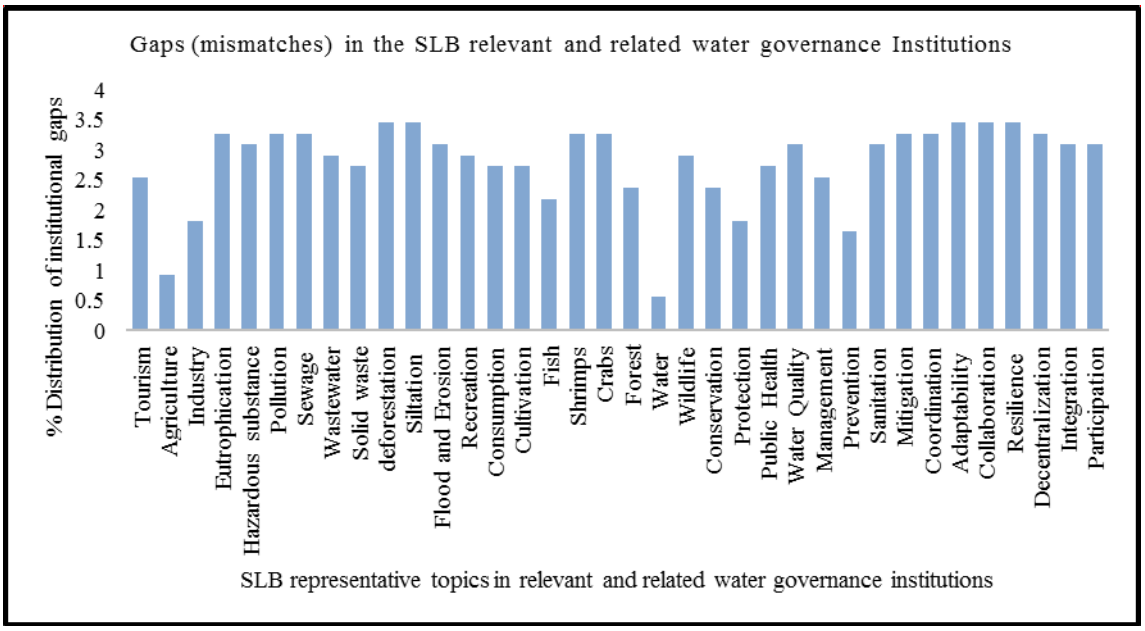


Fig. 6 Gaps (mismatches) in the SLB relevant and related water governance Institutions computed from text mining analysis

One major revelation of the study is that there is no Act of Parliament that establishes the DWR (Fig. 5), but it operates by the 2002 Water Resources Regulations from the Office of the Minister (DWR 2006) [17]. This is unfortunate because regulations are supposed to be drawn from an Act of Parliament (i.e. laws), commonly issued by the Minister (Administrative Court of Thailand 2013) [1], but the DWR has no such legal mandate. The question that begs for answer is how can DWR without an adequate legal mandate influence top player members of the Committees (like Royal Irrigation Department (RID), Royal Forestry Department (RFD), Department of Fisheries (DOF) etc.)? Clearly, simply establishing and formalizing water basin organizations do not immediately translate to integrative and adaptive management of water resources (Shah et al. 2000) [100].

It is then understandable to see why the Ministry of Agriculture and Cooperatives (MOAC) have greater influence and control over water resources management and governance than the Ministry of Natural Resources and Environment (MONRE) who are supposed to be the actual regulators of the sector. MOAC and her departments are the highest users of water resources and consumed more than 57% of the country's 109.3 billion m^3 water resources in 2006 (DEQP 2008) [16]. This makes them both user and regulator of the resources, plus, they are not legally mandated to inform other agencies of their activities (Christensen, and Boon-Long, 1994, Sukhsri 1999, Neef 2008, Kanjina 2008) [8, 103, 84, 54].

The high level of institutional gaps recorded in these studies, especially in the area of the representative terms for integrative and adaptive resource management systems means that the water resources related laws in the SLB are not adaptable to the needs of the ecosystems that will ensure a fair and consistent enforcement of the rules of the game (Kalikoski, et al 2002, Ostrom, et al, 1999, Young, 1999) [53, 92]. The implication of this is serious regulatory failure that can lead to inequalities and conflicts among resource users, widespread evasion, and deterioration of the resources (Hashimoto and Barrett, 1991) [42]. The findings of the stakeholder's survey indicated that the reason for weak enforcement of the rules was as a result of the unsuitability of the existing laws because of absence of specific laws and provisions in them to address the numerous challenges in the Basin (Cookey, et al. 2014) [9].

D. Institutional Priorities

The results revealed that the institutional priorities of the laws under review are more on resource utilization than sustainable governance and wise use (Fig. 7). The resource systems representative terms in the Fisheries and Irrigation laws

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were reading more than 40 percent, the environmental management representative terms were at zero. Also, when the stressors representative terms were about 10 percent in the Environmental laws, the resource management system representative terms were about 5 percent and the integrative and adaptive capacity (represented by AILBM) was zero.

This is probably the brain behind over-exploitation of the resource base of the SLB. An example is the uncontrolled change of land from agriculture to shrimp farms and the destruction of wetlands and mangrove forests for the same purpose. Private economic interests seem to prevail in the priorities for development of the SLB (Chufamanee and Lenholdt 2001, GWP, 2012) [7,37], since the legal instruments and policies authorizing the exploitation of the SLB's resources do not provide for protective measures to prevent adverse effects on the ecosystem, making them unfit for the sustainability of the SLB. Talor et al. (1985) and Tanavud et al. (2001) along with Kriengkajon, (2006), IRCNE (2010) and Doungsuwan et al. (2013) [104, 106, 76, 46, 19] all agree with the findings, pointing out the way the National Development Plan influenced the expansion of shrimp farms and rubber plantations to the detriment of the SLB's sustainability.

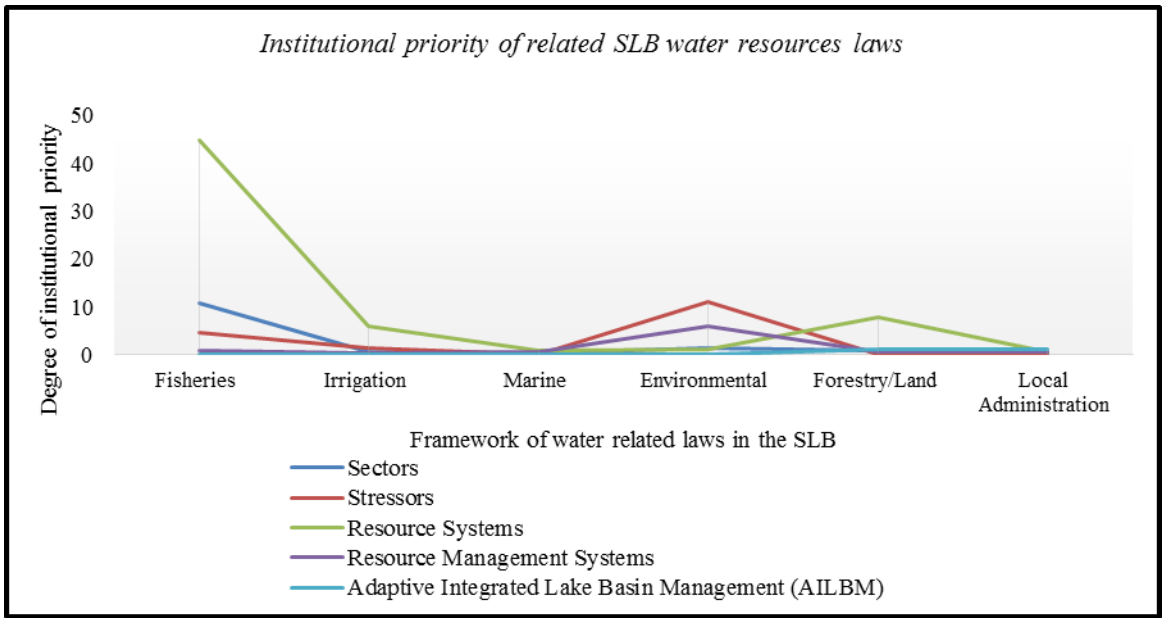


Fig. 7 Framework of institutional priorities of related water governance laws in the SLB, computed from text mining analysis

E. Institutional Capacity to Support Integrative and Adaptive Resource Management

In order to determine the magnitude of the elements of the integrative and adaptive capacity of the current SLB institutions, the representative terms for conventional resources management systems were plotted against the representative terms of integrative and adaptive management and governance (AILBM) (Fig. 8). We found out that the conventional resource management, scored the highest point of about 6 percent (though very low) and the environmental legislations recorded zero percent in the same laws and in the forestry/land laws. The conventional resource management systems were below one percent in fisheries, marine and local administrative laws. This showed that the laws lack all integrative and adaptive elements for effective governance of the SLB.

There is nowhere these kinds of institutions will be able to identify and pursue better and innovative opportunities for organizational learning which the core element of adaptive management is and that is capable of improving resource management systems of the Basin as well as adjusting and adapting to current realities. Folke et al. (2005) [32] re-emphasized that institutions of resource management must be based on knowledge and learning generated by the ecosystems knowledge systems. This study has also clearly shown that most of the resource management institutions in the SLB are obsolete. Even though our studies revealed that most of these institutions have undergone some form of amendments, but their original priorities and intentions as well as their vested interests on resource over-utilization have not really changed.

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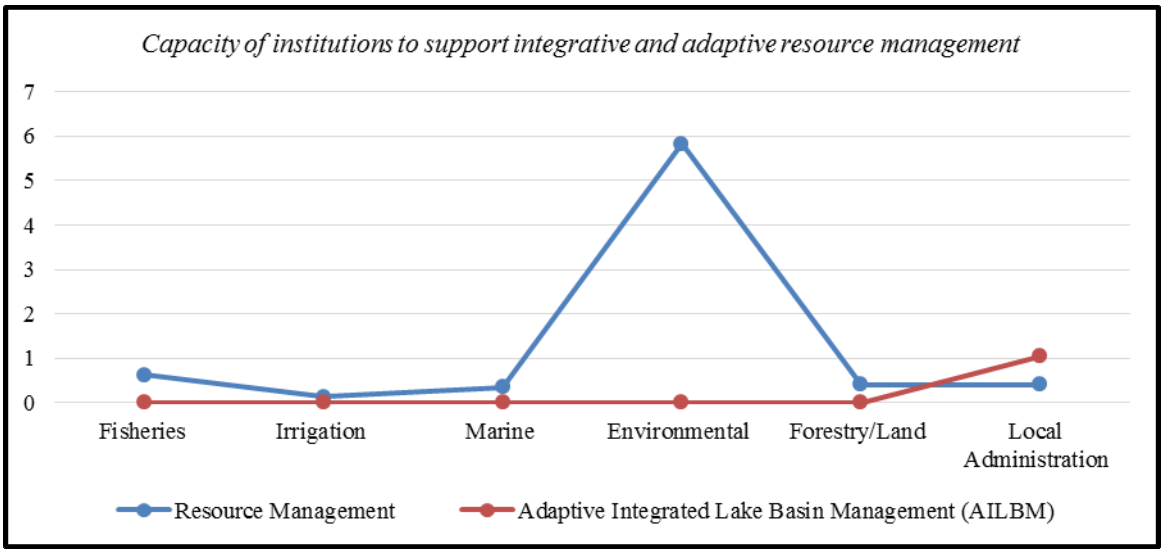


Fig. 8 Capacity of institutions to support integrative and adaptive resource management

V. CONCLUSION

The purpose of this study was to test the use of a quantitative analysis tool like text mining for institutional analysis, and to use this tool to analyse relevant and related water/natural resources governance and management institutions for the SLB, Thailand in order to measure their adaptive and integrative capacity. Hitherto, institutional analysis have been considered strictly a qualitative process, but this research aimed to prove that introducing quantitative analysis can strengthen the results of qualitative analysis and even go further to give expressive and irrefutable data. Agreeably, as many have argued, text mining is not adequate to give insight into the efficacy and efficiency of resources management and implementable because of the wide gap between theory and practice, but arguably, this tool can be a strong complement to collaborate and strengthen other analytical approaches.

Since, institutions are the rules of the game, making them the players' blueprint of resource governance, it is then expected that the way they are crafted and the terms used to express those rules will have a great impact on their implementation. Therefore, it makes sense that analysing institutions to measure their adaptive and integrative capacities should involve assessing the frequencies and densities of related representative terms as they appear in relevant set of institutions. This research work was able to show that the quality of legal operating document for water/natural resources can be quantitatively analysed using text mining tool, and it could also develops equations to determine inherent policy weakness, degree of actors vested interests as well as determine the measure of their suitability for the enhancement of resources governance and management.

The results of this research go a long way to prove the essential nature of the text mining tool in institutional analysis and policy research. Some interesting patterns were revealed by the text mining results; for example, the basic statistics of these laws and the representative terms, the degree of fragmentation, overlaps and gaps, priorities of the institutions and their capacity to support adaptive and integrative elements of resource governance. The institutions that were analysed in the case study were those directly related and relevant to the governance and management of the SLB. The text mining analysis was able to throw up the fact that the existing institutional was not adaptive or integrative, which led to a major recommendation for institutional reviews and reforms of related and core water/natural resources laws for the SLB in particular and Thailand in general.

When considering institutional analysis, we think that it is expedient to review how provisions of the laws can keenly and clearly capture adaptive and integrative elements like resilience, stakeholder participation, organizational and community collaboration, decentralization, integration, adaptability as well as conservation, prevention and conflict management. This will ensure to anticipate future challenges and assimilate future changes, especially in a complex and dynamic ecosystem like lake basins. Now, how can this be achieved if the laws do not contain these elements and other in clear terms or at least closely related terms? How are the implementers (i.e. actors) supposed to understand and acknowledge the importance of such requirements in policy and legal documents if that are not clearly stated? Obviously, to avoid ambiguities, which can lead to bending of rules or just plain ignoring them, lake basin institutions need to contain clear and related adaptive and integrative terms to be considered fit; and text mining representative terms is a sure-fire way to carry out such analysis.

We are not arguing that text mining alone will be enough to do institutional and policy analysis, but the results of this research show that it can be a very important aspect of any such analysis. And even though, some may argue that institutions may be well drafted with all the best intentions, but not properly implemented if at all, because actors choose to operate outside the ambit of the policy and legal provisions, this does not mean that pursuing for well drafted and fit-for-purpose institutions,

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especially for endangered resources like lake basins, should be pushed aside. The world's lakes are facing a huge crisis today and urgent measures are required. No quick fix or ad hoc solution will settle the dust. Hardware fixes alone will not even come close to stemming the deterioration lake basins like the SLB face, unless there is a fit governance system guiding the way things are done and the way actors interact. Research has shown that the current institutional framework for lake basins in most countries, and the SLB, Thailand in particular, are not fit for the complex and dynamic nature of lake basins, and since they are more focussed on exploitation and utilization over conservation and protection, they, therefore, cannot guarantee sustainability. We see these as a major challenge to the wellbeing of lakes today and that is why we recommend that lake basin institutions globally should be reviewed with a focus on the lake basins themselves, their peculiar nature and inherent characteristics.

This makes the text mining analysis tool utmost importance because of its ability to be deployed as a complementary analytical tool at the initial stage of drafting and reviewing new or old policies and legal documents, as well as to determine the real priorities, resource management systems and response capacity of relevant institutions. It is also, relevant for assessing management, standards and procedural documents for the implementation of relevant institutions. Further research can extend to testing the tool and other legal and management documents for lake basin governance. It can also be tested on other policy and legal frameworks for governance in other areas and for other focus apart from adaptability and integration. Even if it just to add credence to the results of qualitative analysis, this tool is an essential keep sake.

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