

Identification Study on Water Management System in Liang Polder, Banjar Regency, South Kalimantan Province

by Ahmad Saiful Haqqi

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Saga, Japan



International Association
of Lowland Technology



Institute of Lowland and
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Preface

The International Symposium on Lowland Technology has been held biennially from 1998 and we reached the 9th meeting at ISLT2014. During the last 18 years, most were held in Saga, Japan. However for this decade it was held in Bangkok, Busan and Bali in 2004, 2008 and 2012, respectively.

When this event was held in attractive cities outside Japan, many participants in the symposium enjoy the atmosphere and ambience of these cities as well as deepen their knowledge on issues involving Lowland. Saga is also still one of typical lowlands in the world, however, touching different features in other lowland areas are also very interesting and informative. Especially, comparing to previous symposium in Bali 2012, that collected 160 papers from 17 countries, the ILMR local organizing committee made great effort for the preparation of the symposium so that we will obtain the result as good as Bali. Finally and fortunately, a total of 130 papers from 11 countries are published in this proceedings.

On average, around 120 papers have been constantly submitted to every past ISLT. It means that many researchers and engineers are interested in lowlands. Furthermore, the term of “lowland” is becoming popular and increasingly has more significant meaning in the era of climate change. Following the same direction, the official journal of IALT, Lowland Technology International, also continues to develop with expanding fields of (i) Geotechnical/Geoenvironmental Engineering, (ii) Water/Environmental Engineering, (iii) City/Urban Planning and Management, (iv) Coastal Science and Engineering and (v) Remedial Measures for Lowland Management.

Those academic publications had played important role in the development of academic disciplines concerning lowlands and thus are essential activities. I hope ISLT2014 in Saga will successfully give fruitful outcome and contribute knowledge to all the participants.



Prof. Hiroyuki Araki
Chairman of Organizing Committee
ISLT 2014 Saga

President's Address

It gives me immense pleasure to welcome all to the 9th International Symposium on Lowland Technology at Saga University, Saga. This symposium follows after the very successful ones at Saga, Busan, Bangkok and Bali. All of us have very fond memories of the very fruitful 8th Symposium in the picturesque resort in Bali. The current one also promises to be equally valuable if not more with more than hundred papers accepted and included for presentation.

ISLT showcases the progress and developments in the field of Lowland and Marine Research with the theme '**Problems and Remedial Measures of Lowlands**' under various topics such as (i) Geotechnical/Geoenvironmental Engineering, (ii) Water/Environmental Engineering, (iii) City/Urban Planning and Management, (iv) Coastal Science and Engineering and (v) Remedial Measures for Lowland Management. More than hundred papers have been received, accepted for publication and presentation. ISLTians can thus look forward to an update on various topics during the Symposium Sept. 29th to Oct. 1st, 2014 in the home grounds of Saga University, the fount for the genesis, nurturing, developing and spreading the knowledge in this area.

It should be noted that nearly twenty five years after the topic is identified for study, the International Society of Soil Mechanics and Geotechnical Engineering is now proposing to have a new Technical Committee on 'Land Reclamation'. I have always felt that just as humans give birth to life and nurture the baby/infant to life, we at IALT, ILMR and erstwhile ILT have been working diligently to create land and making it functional with all attendant concerns in terms of improving the ground, water, environmental, city/urban planning, coastal and sustainability issues.

While remembering the creators and sustainers of IALT, Prof. Miura, Prof. Poorooshab, Prof. Hayashi, Prof. Kim, etc. we all should compliment the present team of Prof. Araki, Prof. Bergado, Prof. Yamanishi, Prof. Hino, Dr. Azizul, Dr. Suman, Dr. Lam and several others for their untiring efforts to make this Symposium a success. Ms Mariko Yahiro, the ubiquitous worker behind the scenes, is a great asset to all our efforts.

Wishing the Symposium a great success with all your presence and participation and looking forward to meet you.



M R Madhav
President, IALT

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CONTENTS

MIURA LECTURE

MIURA LECTURE <i>F.H.M. Van de Ven</i>	1
WATER AND CLIMATE RESILIENCE OF LOWLAND CITIES <i>F.H.M. Van de Ven</i>	2

KEYNOTE LECTURES

WATER QUALITY MODELING FOR WATER MANAGEMENT -INVITATION TO INTEGRAL APPROACH- <i>K. Koga</i>	5
THE FORMATION OF CONCEPTUAL FRAME AND RESEARCH REVIEW OF ASIAN SUSTAINABLE CITY <i>K. Hokao</i>	12

SPECIAL LECTURES

ASSESSMENT OF THE EFFECTS OF SEA-LEVEL CHANGE ON THE GEOENVIRONMENT: THE CASE OF THE ARIAKE SEA COASTAL LOWLANDS <i>T. Hino, J.C. Chai, T. Negami, D.T. Bergado and R. Jia</i>	21
CHANGES IN SUSPENDED SOLIDS IN THE RESERVOIR OF THE ISAHAYA BAY RECLAMATION PROJECT UNDER THE CONTINUOUS SEAWATER INFLOW <i>N. Vongthanasunthorn, Y. Mitsugi, S. Nagase, P.I. Rerkrai, Y. Mishima, K. Koga, H. Araki and H. Yamanishi</i>	31

PART 1

GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

CHAPTER G1: ANALYTICAL METHODS AND NUMERICAL SIMULATIONS

NUMERICAL MODELING INVOLVING BACKFILL GROUTING EFFECTS FOR SEGMENTAL TUNNEL <i>L.G. Lam, H.N. Thi, M. Sugimoto, T. Hino and D.T. Bergado</i>	37
MODEL TESTING AND NUMERICAL SIMULATIONS OF FLOATING TYPE CEMENT- TREATED COLUMNS DURING CONSOLIDATION SETTLEMENT <i>Z. Jiang, R. Ishikura and N. Yasufuku</i>	42
NUMERICAL STUDY ON LATERAL MOVEMENT PATTERN OF BEARING REINFORCEMENT EARTH (BRE) WALL <i>C. Suksiripattanapong S. Horpibulsuk, J.C. Chai, S.L. Shen and A. Arulrajah</i>	50
NON-LINEAR ANALYSIS OF DISPLACEMENTS OF GRANULAR PILE ANCHORS (GPA) IN NORMALLY CONSOLIDATED GROUND <i>B. Vidyaranya and M.R. Madhav</i>	57
ANALYTICAL SOLUTION TO SOIL FLUSHING THROUGH GEOTEXTILE CONSIDERING CLOGGING <i>H.Y. Wang, X.W. Tang, P.L. Gan and B. Niu</i>	65

ANALYSIS AND SIMULATIONS OF FLOOD CONTROL AND EROSION PROTECTION DESIGNS USING THE PLAXIS 2D AND SLIDE PROGRAMS <i>N. Chanmee, D.T. Bergado, T. Hino and L.G. Lam</i>	71
PREDICTION OF SETTLEMENT INDUCED BY MULTI-DIRECTIONAL CYCLIC SHEAR FOCUSED ON PLASTICITY INDEX OF SOFT CLAY <i>Y. Sueyoshi, H. Matsuda, H. Hara, K. Nakahara and T.T. Nhan</i>	79
NUMERICAL SIMULATIONS USING FEM 2D COMPARED TO FEM 3D AND OBSERVED BEHAVIOR OF REINFORCED FULL SCALE EMBANKMENT <i>S. Shrestha, P. Baral, D.T. Bergado, J.C. Chai and T. Hino</i>	85

CHAPTER G2: PROPERTIES OF SOILS

STUDIES ON ENGINEERING PROPERTIES OF LITHOMARGIC CLAYS OF COASTAL KARNATAKA IN INDIA <i>R. Shivashankar, A.U. Ravi Shankar and J. Jayamohan</i>	93
DEPOSITIONAL ENVIRONMENT AND GEOTECHNICAL PROPERTIES OF SHANGHAI CLAYS IN COMPARISON WITH ARIAKE AND BANGKOK CLAYS <i>G.L. Ye, C.J. Wu and Y.L. Yu</i>	101
EVALUATION OF HYDRAULIC CONDUCTIVITY OF SOFT DEPOSIT BASED ON PIEZOCONE TEST <i>J.P. Wang, S.L. Shen, J.C. Chai and Y.S. Xu</i>	108
CHARACTERIZATION OF PEAT IN NORTHERN MANITOBA, CANADA <i>E.M.B. De Guzman and M.C. Alfaro</i>	113
CONSOLIDATION BEHAVIOR OF SATURATED MARINE CLAY UNDER CYCLIC LOADING <i>Y. Kuno, A.T. Tran, H. Hara and H. Matsuda</i>	120
ANISOTROPIC CONSOLIDATION BEHAVIOR AND MICROSTRUCTURE OF ARIAKE CLAY <i>K. Aiga, J.C. Chai and T. Negami</i>	125
THE POST-DEPOSITIONAL ENVIRONMENTAL CHANGES OF ARIAKE CLAY IN SAGA PLAIN <i>R. Jia and T. Hino</i>	131
CYCLIC BEHAVIOR OF MARINE SILTY SAND SUBJECTED TO LONG TERM LOADING <i>J.M. Kim, S.W. Son, T.K. Ryu, S.H. Park and G. Soriano</i>	137

CHAPTER G3A: SOIL/GROUND IMPROVEMENT A

STRENGTH INCREASE OF SOFT CLAY UNDER EMBANKMENT LOADING IN YUHUAN, CHINA <i>H.N. Wu, Y. Yuan, S.L. Shen and Y.S. Xu</i>	144
LABORATORY TESTS ON THE INFLUENCE OF SOIL DISTURBANCE ON THE MATERIAL PROPERTIES OF CEMENT-TREATED SOIL <i>M. Makino, T. Takeyama and M. Kitazume</i>	150
LABORATORY MODEL TESTS OF THE EFFECT OF DECREASE IN PERMEABILITY OF VERTICAL DRAIN ON CONSOLIDATION BEHAVIOR <i>T. Tsuyoshi, T. Takeyama and M. Kitazume</i>	156

CENTRIFUGE MODEL TESTS ON EMBANKMENT ON SOFT CLAY GROUND SUBJECTED TO DREDGED SOIL PRESSURE
Y. Otake, T. Takeyama and M. Kitazume..... 163

PROGRESS SPEED OF DETERIORATION OF CEMENT AND LIME TREATED SOIL IMMERSSED IN SEAWATER
H. Hara, D. Suetsugu and H. Matsuda..... 169

UTILIZATION OF SUGARCANE BAGASSE ASH IN PEAT STABILIZATION
M.K. Abu Talib, N. Yasufuku and R. Ishikura..... 174

SHORT TERM DURABILITY OF CEMENT STABILIZED SANDY SOIL UNDER SEAWATER ENVIRONMENT
R. Ishikura, N. Yasufuku, T. Kono and R. Kurokawa..... 181

CHAPTER G3B: SOIL/GROUND IMPROVEMENT B

NUMERICAL STUDY ON DYNAMIC BEHAVIOR OF COLUMNAR VERSUS LATTICE-SHAPED GROUND IMPROVEMENT
S.S. Lin, C. J. Chien, C.C. Yang and H.C. Lai..... 188

COMPRESSIVE STRENGTH DEVELOPMENT OF CLAY-FLY ASH GEOPOLYMER
P. Sukmak, S. Horpibulsuk and C. Suksiripattanapong..... 196

A STUDY ON THE EFFECT OF SALT ON THE BEHAVIOUR OF COMPACTED BENTONITE
A.K. Mishra and J. Dutta..... 205

SWELLING CHARACTERISTICS OF EXPANSIVE SOILS IMPROVED WITH CEMENT AND FLY ASH
P. Voottipruex, P. Jamsawang, S. Kamkootod and S. Intapichai..... 211

SOIL CEMENT MIX DESIGN TEST FOR URGENT DISASTER REDUCTION OF MT. BAWAKARAENG, INDONESIA
T. Harianto, S.H. Nur, I. Maricar, A.A. Amiruddin and Masriflin..... 218

AN OVERVIEW ON THE FACTORS INFLUENCING THE COMPRESSIBILITY CHARACTERISTIC OF CEMENT-BENTONITE MIXTURE SLURRY SAMPLES
M. A. Walenna, and L. Samang..... 224

MODEL TEST OF THE TIMBER RAFT AND PILES COMPOSITE FOUNDATION COMBINED WITH THE VERTICAL DRAIN
J. Sasaki, D. Suetsugu and S. Manandhar..... 231

CHAPTER G3C: SOIL/GROUND IMPROVEMENT C

A NOVEL GREEN CONSTRUCTION MATERIAL FROM WATER TREATMENT SLUDGE
S. Horpibulsuk, C. Suksiripattanapong, P. Chanprasert, P. Sukmak and A. Arulrajah..... 235

EFFECTS OF GROUND IMPROVEMENT ON LOW ALKALINE STABILIZER WITH RECYCLED PLASTER
S. Sugimoto, K. Omine and Y. Jiang..... 240

FEASIBILITY OF STEEL SLAG-FLY ASH-DOLIME MIX AS A BASE COURSE MATERIAL FOR FLEXIBLE PAVEMENTS
S. Patel, J.T. Shahu and T.R. Naik..... 245

EVALUATION OF LIGHTWEIGHT DEFLECTOMETER TESTS ON THIN SURFACE PAVEMENT BY USING MULTI-LAYER LINEAR ELASTIC ANALYSIS <i>T. Posribink, S. Youwai and W. Kongkitkul</i>	254
THE EFFECT OF ENVIRONMENT CHANGE ON THE STRENGTH OF CEMENT TREATED GROUND AND ITS ADJACENT GROUND <i>T. Himeno, T. Negami, R. Jia and T.Hino</i>	262
THE EFFECT OF WATER CONTENT REDUCTION TO FIBROUS PEAT ABSORBENT CAPACITY AND ITS BEHAVIOUR <i>F.E. Yulianto, F. Harwadi and M.K. Wardani</i>	266
PERFORMANCE OF WASTE QUARRY BY-PRODUCTS AS A SUPPLEMENTARY RECYCLED SUBGRADE MATERIAL <i>S. Manandhar, D. Suetsugu, H. Hara and H. Hayashi</i>	271

CHAPTER G3D: SOIL/GROUND IMPROVEMENT D

STRENGTH RESPONSE OF FLY ASH MIXED WITH PLASTIC WASTE UNDER STATIC AND DYNAMIC LOADING <i>G.L. Sivakumar Babu and R. Pratibha</i>	279
METHODOLOGY FOR CALCULATING THE CONSOLIDATION SETTLEMENT OF FLOATING SOIL-CEMENT COLUMN IMPROVED SOFT CLAYEY DEPOSIT <i>S. Pongsivasathit, P. Jitsuwan, J.C. Chai and T. Hino</i>	285
RUZI GRASS COMBINED WITH WATER HYACINTH WOVEN LIMITED LIFE GEOTEXTILES (LLGS) FOR SOIL EROSION CONTROL <i>S. Artidteang., D.T. Bergado, S. Chaiyaput and L.G. Lam</i>	294
APPLICATION OF 8R MAT FOR SLOPE PROTECTION AND SOIL EROSION CONTROL <i>F. Ahmad</i>	300
STUDY OF QUARTZ MINERAL BASED ON SMEAR SLIDES IN BILI BILI DAM OF PARANGLOE, GOWA DISTRICT OF SOUTH SULAWESI PROVINCE <i>H. Hamrullah, I. Alimuddin, H. Umar and H. Pachri</i>	308
PERFORMANCE OF PVDS IMPROVEMENT WITH AND WITHOUT VACUUM FOR SOFT GROUND <i>L.G. Lam, D.T. Bergado, P. Voottipruex, J. Saowapakpiboon and T. Hino</i>	313
CHARACTERISTICS OF WET-DRY CYCLES OF COMPACTED EXPANSIVE SOIL-FIBER MIXTURE <i>S.H. Nur, T. Harianto and A. Cakra</i>	318

CHAPTER G4: SOIL REINFORCEMENT/GEOSYNTHETICS

PERFORMANCES OF GEOSYNTHETIC REINFORCEMENT ON THE BALLASTED RAILWAY TRACK-MODEL TEST <i>L.S. Sowmiya, J.T. Shahu and K.K. Gupta</i>	326
GEOSYNTHETIC REINFORCED STONE COLUMNS IN SOFT SOILS: AN EXPERIMENTAL AND ANALYTICAL STUDY <i>K. Ali, J.T. Shahu and K.G. Sharma</i>	332
ANALYSIS OF OBLIQUE PULL IN REINFORCED SOIL WALL – COHERENT GRAVITY AND TIEBACK WEDGE METHODS <i>P.V.S.N.P. Kumar, M. R. Madhav and M. Kumar</i>	340

A NEW ANALYSIS OF REINFORCED SOIL WALL RESTING ON SOFT GROUND <i>S. Patra and J.T. Shahu</i>	348
FURTHER MODIFICATION K-STIFFNESS METHOD ON SOFT AND HARD FOUNDATIONS <i>S. Duangkhae, D.T. Bergado, J.C. Chai and T. Hino</i>	353
CASE STUDY OF REINFORCED UNSTABLE SLOPE IN SOFT CLAY USING MICROPILE <i>A. Arsyad, L. Samang T. Harianto, Ahmad and O. Tenta</i>	361
ROOT STRENGTH OF VETIVER AND RUZI GRASSES FROM IN-SITU TESTS <i>J. Maneecharoen, W. Hwte, D.T. Bergado, T. Hino and N.T.N. Truc</i>	367

CHAPTER G5: FOUNDATIONS ON IMPROVED SOILS

EXPERIMENTAL STUDY OF SANDY CLAY REINFORCED BY GROUTED SAND COLUMN <i>L. Samang, A.B. Muhiddin, A. Arsyad, R. Abdullah and N. Dhani</i>	373
KINEMATICS AND BEARING CAPACITY OF STRIP FOOTING ON REINFORCED GRANULAR BED OVER SOFT GROUND STABILIZED WITH GRANULAR TRENCH <i>R. Kurapati, S.V. Abhishek and M.R. Madhav</i>	377
APPROPRIATENESS OF PILED RAFT FOUNDATION FOR TALL STACK-LIKE STRUCTURES IN COASTAL AREAS <i>B.R. Jayalekshmi, S.V. Jisha and R. Shivashankar</i>	385
PERFORMANCE OF STONE COLUMN REINFORCED SOFT CLAY UNDER CYCLIC AND STATIC LOADING <i>S. Kumar and J.T. Shahu</i>	393
CONSIDERATION OF INDUCED OVERCONSOLIDATION ON RESPONSE OF GRANULAR PILE REINFORCED SOFT GROUND <i>K. Suresh, M.R. Madhav and E.C. Nirmala Peter</i>	397
FULL-SCALE TRIAL EMBANKMENT ON SOFT SOIL REINFORCED WITH INCLINED PILE <i>Suheriyatna, L. Samang, M.W. Tjaronge and T. Harianto</i>	404
A FULL SCALE EXPERIMENTAL STUDY OF PILE-PVD (HYBRID PILE) REINFORCEMENT OVER SOFT SOIL <i>Y. Sandyutama, L. Samang, A.M. Imran and T. Harianto</i>	410

CHAPTER G6: SOIL GEOHAZARD AND GEOENVIRONMENT IN LOWLANDS

MITIGATIONS OF MULTI-HAZARDS IN LOWER CHAO PHYA RIVER BASIN, THAILAND <i>S. Soralump</i>	416
DEWATERING EFFECT ON SURROUNDINGS DURING DEEP EXCAVATION IN SOFT DEPOSIT OF TIANJIN, CHINA <i>Y.X. Wu, S.L. Shen and Y.S. Xu</i>	423
GEO TECHNICAL CHARACTERIZATION OF THE SUBSOIL PROFILE UNDERLYING THE LAND SUBSIDENCE MONITORING POINTS IN SOUTHERN VIETNAM DELTA <i>P.H. Giao, T.T. Thoang, L.X. Thuyen and N.N.N. Vu</i>	429
SYSTEM FOR MONITORING ADAPTATION TO CLIMATE CHANGE-INDUCED DISASTERS IN COASTAL REGIONS <i>K. Yasuhara, K. Kuwahara and D.M. Duc</i>	437

SEDIMENT ACCUMULATION IN THE KULEKHANI RESERVOIR DUE TO THE 1993 DEBRIS FLOWS AND LANDSLIDES <i>M.R. Dhital, S. Manandhar, T. Hino and D. Suetsugu</i>	443
COASTAL EROSION IN TAKALAR BEACH SOUTHERN MAKASSAR, INDONESIA <i>R. Langkoke, B. Rochmanto, J.R. Husain and M. Akbar</i>	451
EFFECTS OF ACID TREATMENT AGENT AND SALINITY ON TRANSPARENCY OF THE ARIAKE SEA <i>K. Tsukamoto, D. Suetsugu, S. Manandhar and H. Hara</i>	461
CONCURRENT BIOELECTRICITY AND GEOENVIRONMENTAL IMPROVEMENT OF ACID VOLATILE SULFIDE SEDIMENT <i>M.A. Moqsud, Y. Kanehagi and M. Hyodo</i>	466

PART 2

WATER AND ENVIRONMENTAL ENGINEERING COASTAL ENGINEERING

CHAPTER W1: GROUNDWATER AND SOIL CONTAMINATION MANAGEMENT

MODELING OF SEAWATER INTRUSION REDUCED IN UNCONFINED AQUIFER WITH PHYSICAL BARRIER <i>Nurnawaty, M. Selintung, A. Thaha and F. Maricar</i>	471
MODELING THE EFFECT OF LEAKY SEWER ON GROUNDWATER MICROBIAL QUALITY <i>N. Seetha, G.R. Anjana and M.S. Mohan Kumar</i>	476
APPLICATION OF ASTAR AND RBF-NN TO PREDICT LOCATION AND MAGNITUDE OF PIPE LEAK ON WATER DISTRIBUTION NETWORK <i>A.E.U. Salam, M. Tola, M. Selintung and F. Maricar</i>	481
THE INFLUENCE OF GIVING LIME AND FERTILIZER TO THE WATER QUALITY OF THE ACID-SULPHATE AGRICULTURE LAND MODEL <i>A. Rusdiansyah, N. Helda and Rismawidha</i>	487
BIOREMEDIATION OF SOIL CONTAMINATED WITH RESIDUAL FUEL OIL BY NITRATE ADDITION <i>S. Leungprasert and M. Suknij</i>	492
GIS-BASED STATISTICAL ANALYSES OF DIRECT SURFACE WATER-GROUNDWATER CORRELATIONS IN THAILAND <i>A. Putthividhya, S. Jirasirilak, A. Amto and S. Petra</i>	496
NUMERICAL MODEL OF AN AQUIFER THERMAL ENERGY STORAGE SYSTEM WITH MULTIPLE WELLS <i>S. Ganguly and M. S. Mohan Kumar</i>	504

CHAPTER W2: WASTEWATER AND WASTE MANAGEMENT

FIELD INVESTIGATION ON THE DECENTRALIZED WASTEWATER TREATMENT PLANTS CONSTRUCTED TO IMPROVE SANITATION CONDITION IN KHULNA <i>S. R. Saha and M. Alamgir</i>	510
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THE BENEFITS OF PADDY HUSK BRIQUETTES AS ABSORBER IN THE DISTILLATION PROCESS <i>H.U. Syarif, D.A. Suriamiharja, M. Selintung and A.W. Wahab</i>	518
THE INVESTIGATION OF CATIONIC DYE ADSORPTION ON THERMAL AND CHEMICAL ACTIVATED ADSORBENTS FROM WATER SUPPLY SLUDGE AND ASHES FROM BIOMASS POWER PLANT <i>S. Polruang, P. Banjerdikij and S. Sirivithayapakorn</i>	523
SYNTHESIS OF HYBRID ADSORBENT CONTAINING NANO-SIZE HYDROTALCITE AND ZEOLITE AND BASIC PERFORMANCE <i>M. Ohno, Y. Kobayashi, H. Suhara, S. Juengjarernnirathorn, Y. Mishima and H. Araki</i>	530
EVALUATION ON APPLICABILITY OF A NEW HYBRID ADSORBENT TO WATER POLLUTION CONTROL IN LOWLAND BY COMPLEX LEACHATE FROM WASTE LANDFIL SITE <i>S. Juengjarernnirathorn, M. Ohno, Y. Mishima, H. Suhara and H. Araki</i>	536
EFFECTS OF METAL LOADING ON THE PHOTOCATALYTIC NITRATE REDUCTION EFFICIENCIES OF TiO ₂ CATALYST <i>K. Kobwittaya and S. Sirivithayapakorn</i>	543
BIOGAS PRODUCTION FROM CO-DIGESTION OF MUNICIPAL WASTEWATER AND FOOD WASTE IN BANGKOK, THAILAND <i>P. Banjerdikij, S. Polruang and S. Sirivithayapakorn</i>	548

CHAPTER W3: FLOOD ANALYSIS AND MANAGEMENT

ONLINE ESTIMATION OF FLOOD DAMAGE IN THE NETHERLANDS <i>O.A.C. Hoes, M.A.U.R. Tariq and N.C. Van de Giesen</i>	553
A STUDY ON RIVER BASIN MANAGEMENT IN JOBARU RIVER BASIN BY COMPUTATIONAL SIMULATIONS OF FLOOD AND SEDIMENT TRANSPORT AND FIELD GEOTECHNICAL INVESTIGATIONS <i>H. Nakashima, K. Ohgushi, T. Hino, T. Morita and T. Jansen</i>	559
EVACUATION AND FLOOD SIMULATIONS IN THE CASE THAT SHELTERS ARE INCLUDED IN LOWLAND AREA <i>T. Morita, K. Ohgushi and A.H. Thambas</i>	566
DEVELOPMENT OF FLOOD ROUTING MODELS FOR YOM RIVER BASIN <i>W. Liengcharensit, R. Charoensuk, P. Siripanaroj and P. Ruekraai</i>	572
PERCEPTION OF FLOOD-PRONE COMMUNITIES IN PROBLEMATIC OF FLOOD RESPONSE: CASE STUDIES IN BANGKOK AND NONTHABURI PROVINCE <i>I. Raungratanaamporn</i>	578
ALTERNATIVE SOLUTIONS OF FLOOD AND WASTE MANAGEMENT IN MANADO, "ECO-TOURISM" CITY <i>A.K.T. Dundu, K. Ohgushi and R.J.M. Mandagi</i>	586

CHAPTER W4: PROBLEM ANALYSIS IN RIVER BASIN AND COASTAL AREA

CHANGE DETECTION OF VEGETATION USING LANDSAT IMAGERY IN MODIFIED AJKWA DEPOSITION AREA (MOD-ADA) AT FREEPORT INDONESIA LTD IN PAPUA INDONESIA <i>Y. Windusari and S.P. Sari</i>	593
--	-----

COMPARISON OF METHODS OF EXTRACTION OF WATER BODIES FROM META DATA <i>N. Nawaz , S. Sanaga and P.K. Rao</i>	597
SCOUR REDUCER MODELING BY USING CURTAIN RECTANGULAR WITH WEDGE CURVE SHAPE (RWWSC) AT PILLAR ZONA <i>Nenny, S. Pallu , A. Thaha and F. Maricar</i>	601
ASSESSING WADEABLE STREAMBANK STABILITY OF THE KODKU RIVER, KATHMANDU USING MORPHO-HYROLOGIC PARAMETERS AND BANK EROSION POTENTIAL <i>N.K. Tamrakar, R. Bajracharya, and S. Manandhar</i>	609
COASTAL VULNERABILITY BASED ON TECTONICS AND SHORELINE CHANGE ALONG COASTAL AREA OF LUMPUE COAST SOUTH SULAWESI <i>H. Sirajuddin, D.A. Suriamihardja, A.M. Imran, and M.A. Thaha</i>	617

CHAPTER W5: WATER RESOURCES AND WATER ENVIRONMENT

POTENTIAL CONTRIBUTION OF HYDRO POWER PLANTS TO THE ENERGY CONSUMPTION OF EAST ASIAN ISLANDS <i>O.A.C. Hoes, L.J.J. Meijer, D.R. Sarfianto and R.J. Van der Endt</i>	622
IDENTIFICATION STUDY ON WATER MANAGEMENT SYSTEM IN LIANG POLDER, BANJAR REGENCY, SOUTH KALIMANTAN PROVINCE <i>N. Fithria, N. Helda and N. Amal</i>	628
WATER RESOURCES GOVERNANCE BASED ON AN INTEGRATED LAKE BASIN MANAGEMENT APPROACH <i>S. Silva, A. Bernal, M. Ortíz and G. Cuevas</i>	637
PREDOMINANT ALGAE IN BANG PHRA RESERVOIR: MORPHOLOGICAL AND MOLECULAR IDENTIFICATION <i>P. Suwanvitaya and S. Suwan</i>	646
LONG-TERM CHANGE OF SUSPENDED SOLIDS IN THE INNERMOST PART OF THE ARIAKE SEA <i>S. Nagase, N. Vongthanasunthorn , Y. Mishima, H. Araki and K. Koga</i>	652
THE STUDY OF CHAETOCEROS BLOOMING AND WATER QUALITY MONITORING IN CHONBURI BAY <i>P.I. Rerkrai and W. Liengcharernsit</i>	658
INFLUENCE OF ARTIFICIAL TRENCHES ON HABITAT IN A TIDAL AREA <i>Y. Nagahama, K. Nishimura, A. Kitsuka and H. Yamanishi</i>	664
THE RELATIONSHIP OF PHYSICAL ENVIRONMENT AND HYDRAULIC CONDITIONS ON FISH FAUNA <i>R. Lopa and Y. Shimatani</i>	670

**PART 3
CITY/URBAN PLANNING AND MANAGEMENT**

CHAPTER U1: SUSTAINABILITY

DEVELOPMENT OF CRIME RISK ASSESSMENT FOR COMMUNITY SAFETY DESIGN <i>M. Kinashi</i>	677
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MULTIVARIABLE CLASSIFICATION OF MORPHOLOGY VULNERABILITY TYPES AND CHARACTERISTICS ON CULTURAL HERITAGE IN AYUTTHAYA, THAILAND <i>W. Daungthima and K. Hokao</i>	685
MANAGING RISK IN THE ROAD MAINTENANCE WORK: A CASE STUDY OF PERFORMANCE BASED CONTRACT <i>B. Mochtar, H. Parung, J. Patanduk and N. Ali</i>	691
RISK STUDY IN IMPLEMENTATION FRAMEWORK AGREEMENT CONSTRUCTION IN EAST KALIMANTAN: REVIEW OF THE PROJECT CYCLE <i>Habir, H. Parung, M. R. Rahim and M. Amri</i>	697
RISK ALLOCATION MODEL ON PUBLIC PRIVATE PARTNERSHIP (PPP) AIRPORT INFRASTRUCTURE DEVELOPMENT IN INDONESIA <i>R.U. Latief, S. Pallu, S.A. Adisasmita and S.H. Aly</i>	705
EXPLORE THE IMPACT OF SEA LEVEL RISE ON URBAN TRANSPORT PROJECTS <i>S. Zhou and W. Li</i>	714

CHAPTER U2: COMMUNITY PLANNING

REVISITING THE GARDEN CITY CONCEPT TO DESIGN THE SUSTAINABLE CITIES OF THE 21 ST CENTURY: THE CASE OF PUTRAJAYA CITY, MALAYSIA <i>S.A. Silva and M.A. Ortiz</i>	719
NEIGHBORHOOD CHARACTERISTICS OF AN ETHNIC BANTIK COMMUNITY IN INDONESIA <i>P.P. Egam, N. Mishima, R. Goto and Y. Taguchi</i>	725
AN ANALYSIS ON CURRENT QUALITY OF LIFE IN AN OLD TOWN WATER DISTRICT: VIEWING IN A CASE OF KHLONG BANG LUANG FROM COMMUNITY CONDITION AND WATER CONDITION <i>T. Tanachawengsakul and N. Mishima</i>	734
THE SELF-ORGANIZATION SYSTEM OF LOW-INCOME INDIVIDUAL INTEGRATION INTO LOWLAND CONDITIONS <i>U. Shummadtayarand K. Hokao</i>	743
STUDY ON METHODOLOGY OF THE ASSESSMENT OF URBAN RESIDENTIAL ACOUSTIC ENVIRONMENT <i>M. Zhu</i>	751
RENOVATION AND SUSTAINABLE DEVELOPMENT OF THE RURAL HOUSES: TAKING THE LONGHOUSE'S RENOVATION IN ZHANG LUWAN VILLAGE OF CHINA AS EXAMPLE <i>C. Chen, Z. Wang and L. Wang</i>	755

CHAPTER U3: PLANNING

MOVING FORWARD TO WALKABILITY OF TRANSIT ORIENTED DEVELOPMENT (TOD): A CASE STUDY OF BANGKOK METROPOLITAN, THAILAND <i>P. Iamtrakul and Kritayanukul</i>	760
USE BALANCED SCORECARD FOR MEASURING COMPETITIVE ADVANTAGE OF INFRASTRUCTURE ASSETS OF STATE-OWNED PORTS IN INDONESIA: PELINDO IV, MAKASSAR BRANCH <i>N. Hamid</i>	766

THE IMPACT OF URBAN SPRAWL ON CULTIVATED AREA IN RIVER CITY OF CHIANG MAI <i>N. Srinurak and N. Mishima</i>	774
AN URBAN ECOLOGICAL CLASSIFICATION SYSTEM FOR PLANNING DECISION MAKING IN BANGKOK <i>S. Siewwuttanagul, M. Srivanit, P. Iamtrakul and H. Li</i>	781
CONTINUATION AND RECONSTRUCTION STRATEGY OF “TOWN VILLAGE”- A CASE STUDY OF ZHONG CUN VILLAGE PLANNING <i>J. W. Yan, Z. Wang and L. Wang</i>	789
STUDY ON THE STRATEGY OF RURAL DESIGN AND PLANNING OF ZHEJIANG PROVINCE BASED ON THE LANDSCAPE CHANGE DRIVING FORCE RESEARCH <i>H. Shen and Z. Wang</i>	796

CHAPTER U4: CULTURE HERITAGE

CARBON FOOTPRINT FOR ENGINEERING DEPARTMENT, KASETSART UNIVERSITY, COMPARISON BETWEEN NORMAL YEARS AND 2011 WITH THAILAND FLOOD <i>C. Soralump</i>	801
RESEARCH OF UPDATED STRATEGIES ON OLD COMMUNITIES LOCATED IN CITY CENTER AREA: A CASE STUDY OF ZHU ZI FANG COMMUNITY IN FUZHOU, FUJIAN <i>Y. Zheng and Z. Wang</i>	806
STRATEGY OF COASTLINE LANDSCAPE DESIGN TO COPE WITH THE RISING SEA LEVELS <i>Y. Ma</i>	810
COASTAL AND WATERFRONT PLANNING STRATEGIES BASED ON THE SEA-LEVEL RISE <i>Y. Yang</i>	813
MICROSTRUCTURE CHARACTERISTIC AND COMPRESSIVE STRENGTH OF SELF COMPACTING CONCRETE USING SEAWATER AS MIXING WATER <i>Erniati, M.W. Tjaronge, R. Djamaluddin and V. Sampebulu</i>	817
EFFECT OF GFRP BELT TO THE FAILURE MODE OF CRACKED CONCRETE BEAMS STRENGTHENED USING GFRP SHEET <i>R. Djamaluddin and A.M. Akkas</i>	823
Authors' Index	829

IDENTIFICATION STUDY ON WATER MANAGEMENT SYSTEM IN LIANG POLDER, BANJAR REGENCY, SOUTH KALIMANTAN PROVINCE

N. Fithria¹, N. Helda² and N. Amal³

ABSTRACT: Banjar Regency had encountered flooding problem for the last several years. Polder Liang became one of the solutions in Banjar Regency which had been built since the Dutch Colonization. However, in its current condition, the area that supposed to be developed as retention ponds cannot be function optimally; it was caused by water level control and waterworks system. The methods of this research include: field surveys, problem identification, problem definition, literature review, data collection, and analysis of hydrological data. Survey and investigation include tracking and waypoint GPS, then represent to ArcGIS software. Furthermore, hydraulics analysis was used to calculate flow design and Liang Polder's channels. The result of the study is to develop a database of Liang Polder. From the research, it is known that Liang Polder covers large area about 1.412,8 Hectares is potentially area but it is unable to optimally function because the number of water gates (5 main sluice gates and 20 small sluice gates). Nevertheless, one important role for input and output water in the polder is the work of water gates. Consequently, it needs to optimize the operational and maintenance sector, especially for retention areas when rainy season comes.

Keywords: Polder, water management system, water gates, retention area

INTRODUCTION

As one of lowland area in Indonesia, South Kalimantan has a number of polders which were built in the colonial era. Nowadays, one of the polders that is under the authority of the Local Government and has an area of 1000 ha - 3000 ha is Liang Polder. It is located in Martapura, Banjar Regency, South Kalimantan Province, Indonesia as can be seen in Fig. 1.

At one hand, large areas of lowlands in South Kalimantan are not yet well developed where on the other hand their potential might lead to food production and other utilization. Liang Polder is an existing irrigation area which is being developed on an ongoing project basis. Currently, South Kalimantan Provincial Government delegates Department of Public Works South Kalimantan province to empower and manage the polder. Liang Polder Rehabilitation Area of 700 Hectares is the key target in 2013.

Rehabilitation in Liang Polder is due to the current flooding problems that Banjar District is still facing off. Based on the data from the Regional Disaster Management Agency it was recorded that the frequency

of flood occurred 9 times in the year 2012, thus caused a great loss in 9 districts in Banjar (Fakhruzzein 2012).



Fig. 1 Location map of Liang Polder

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Polder Liang has an area of 1412.8 Hectares and surrounded by a paved road embankment and has 25 water gates. There are many rivers around the polder namely: Arpat, Antasan, Bincau, Antasan Ambawang Besar, Baku River respectively (Department of Public Works, South Kalimantan 2011).

Swamp Aspects

Marsh can be distinguished on the tidal marsh and swamp non tides. Tidal marsh (Noor 2004) is defined as the swampy areas which are influenced directly or indirectly by the ebb and flow swing of sea water and/or surrounding rivers. While the swampy marsh (Noor 2007) is the area of land that has a pool of nearly all year round for at least three months with a pool of at least 50 cm high. Swampy marsh is used or cultivated for agricultural development, including fisheries and livestock, therefore it is also called swampy wetlands. Because of its position that is far away from the estuary entrance/large rivers, lowland swamps are often referred to as inland marsh.

Based on the height and duration of inundation (Noor 2007), swampy wetlands can be divided into three types, namely (1) shallow valley, (2) mid valley, and (3) deep or very deep valley.

Swampy bogs and lakes have very important environmental functions with respect to flooding, especially during high rainfall intensity. The surface area of swampy bogs or lakes act as water reservoir which store large amount of water while it does not yet flow into rivers permanently. Besides, swampy surroundings and the lake also function as a catchment area.

Polder System

Polder is defined as an area or a land reclamation with the initial condition has a high water table, which is isolated hydrologically from the surrounding area and the water level (surface water and ground water) can be influenced according to the conditions which were left on their original land elevation or slightly elevated.

Isolation can be done to prevent water that comes from outside the polder. The water in the polder is controlled by drainage system or sometimes in combination with irrigation system.

The components that must exist on the polder system include:

1. Embankment and Sea defense
2. Field drainage system
3. Conveyance system
4. Outfall system
5. Recipient waters

Polder system needs proper management. Polder management, operation and maintenance are intended to prevent a decline in the function of all the elements that exist in the polder system, covering dikes, drainage network, tendons pool, pump stations, and receiving waters

OBJECTIVES

The study was conducted to:

- a. To identify the existing condition of the water system in the Polder Liang.
- b. To analyze the function of Polder Liang Polder as agricultural areas during the dry season and as a retention area in the wet season.
- c. To determine the appropriate method for the operational and maintenance of Liang Polder.

METHODOLOGY

The study consists of two sets of works as follows:

- 1) Identification of Liang Polder
- 2) Liang Polder Data Processing

The methods of this research include: field surveys, problem identification, problem definition, literature review, data collection, and analysis of hydrological data. Survey and investigation include tracking and waypoint GPS, then represent to ArcGIS software.

The flowcharts of Identification Study and Data Processing of Liang Polder are represented in Fig. 2 and Fig. 3.

RESULTS AND DISCUSSIONS

Field Surveys

Field surveys were conducted to review the study site directly in order to obtain documentation of the conditions in the study area associated with:

1. Identification of the water system at Liang Polder.
2. Irrigation facilities that exist in the Polder Liang.
3. Area utilization/optimization and maintenance of polders by residents.
4. Environmental conditions and settlements around the Polder.

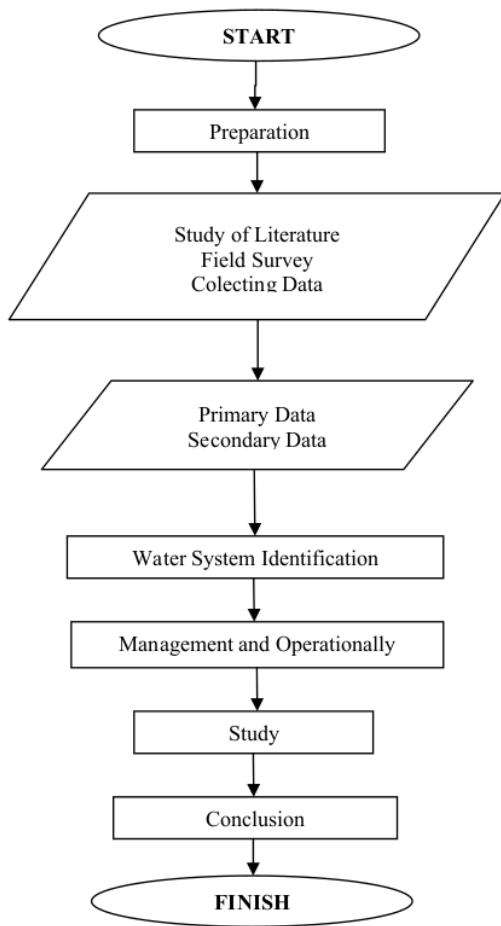


Fig. 2 Flow chart of identification study of Liang Polder

Data Inventory

From the field surveys, it is known that Liang Polder is located on geographical coordinates of 3°24'06.98" South Latitude and 114°53'32.04" East Longitude with an area of 1412.8 Hectares. General and Technical Data of Liang Polder is shown in Table 1. It has 5 main gates and 20 small gates in good condition (except main gate 3, 4 and 5) with the dikes length of 17.5 kilometers. Liang Polder is a polder which can be used for agriculture land in dry season and as a retention pond in rainy season.

Water System Identification

Based on the observations, it can be identified that Liang Polder is a semi- technical Polder. It is still

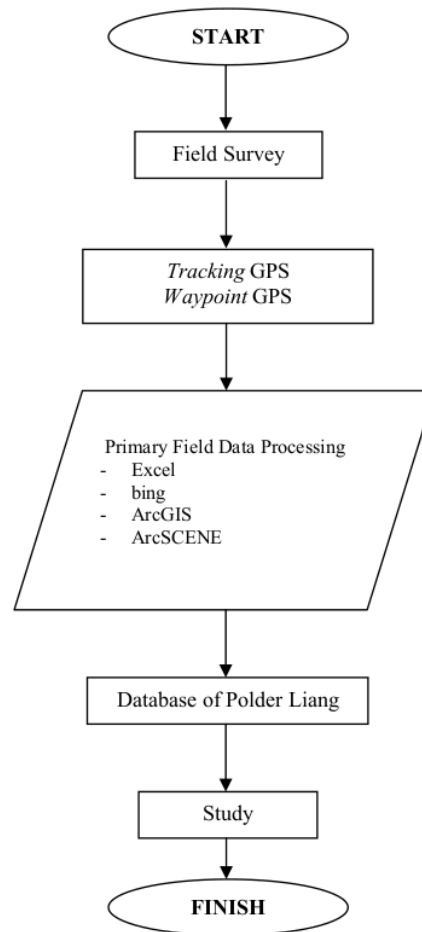


Fig. 3 Flow chart of Liang Polder Data processing

manually operated, also the irrigation and drainage channels are not completely separated.

Liang Polder area has six rivers that flow inside and outside the polder. The first river is a Liang River, then Arpat River, Besar River, Antasan Ambawang River, Baku River and Antasan River with a length of about 5404 m, 1354 m, 697 m, 1936 m, 309 m and 245 m respectively. The detailed flow and topography of Liang Polder are shown in Figs. 4 and 5.

It is also known that from 25 water gates, 40% are in good condition for 8 small gates and 2 main gates, 40% are in not good condition for 10 small gates and the last 20% are in the improvement process for 2 small gates and 3 main gates. The detailed condition of all water gates is explained in Table 2.

In addition to dikes, polder water system is also supported by the water gate surrounding the polder. When the water level rose during heavy rainfall exceeds

Identification study on water management system in Liang Polder

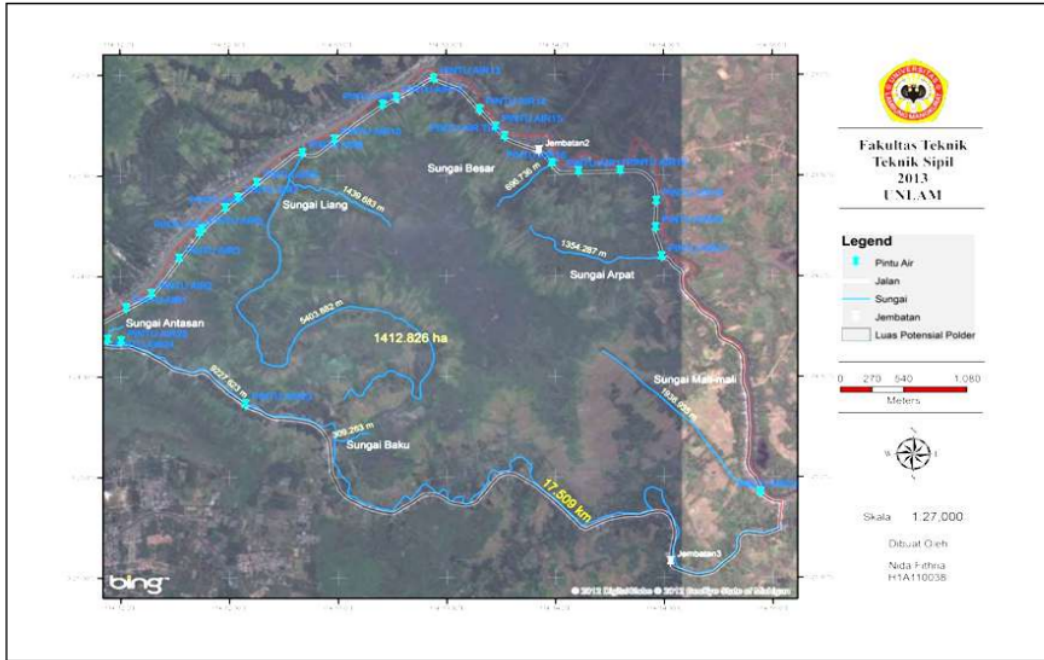


Fig. 4 Details of river flow and water gates

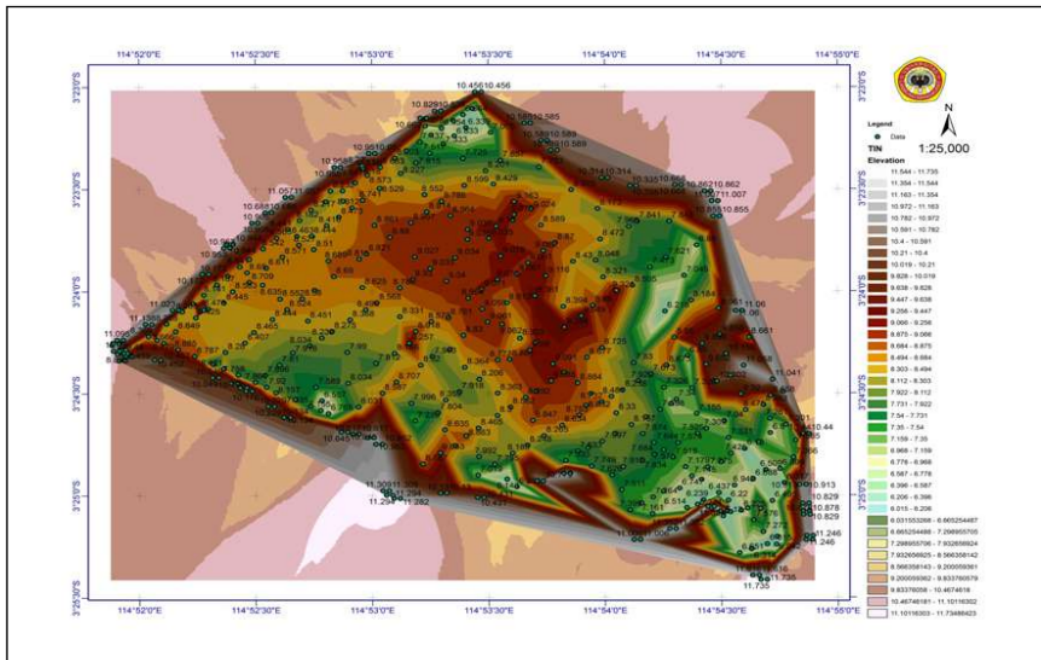
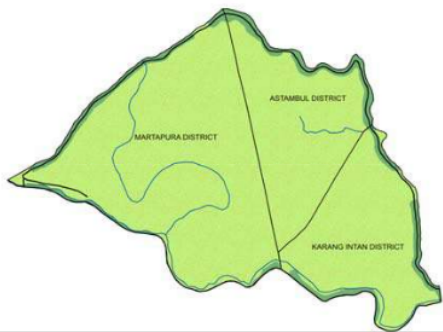


Fig. 5 Topography map of Liang Polder

Table 1 General and technical data of Liang Polder

General and Technical Data Polder Liang		
Data Infrastructures Polder Liang		
District :	1. Martapura 2. Karang Intan 3. Astambul	
Name :	Polder Liang	
No	Item	Description
1	Polder Area	1412.8 ha
2	Coordinates	3°24'06.98" S and 114°53'32.04" E
3	Number of Villages	12 villages
4	Existing building types	Main Sluice Gate : 5 gates Small Sluice Gate : 20 gates Dikes Lenght of Liang Polder : 17.5 kilometers.
5	Rivers around the Polder	1. Sungai Bincau 2. Sungai Martapura 3. Sungai Riam Kanan
6	Utilization of Polder	1. As agricultural land in the dry season 2. As a retention area in the rainy season
7	Rivers in Polder Liang	1. River Liang 2. River Arpat 3. River Antasan 4. River Antasan Ambawang 5. River Besar 6. River Baku
8	Liang Polder Delineation	Digitation Map of Liang Polder (Source : Bakosurtanal 1999)



the capacity, the polder system will work with the operation of water gate manually to open the gate so that water can drain out the water until the water in the polder areas in the polder in normal circumstances.

All the main gates at the Polder during the rainy season serves as an outlet to the river channel around

Table 1 Items of three variables

No	Gate	Count	Width (m)	Condition
1	Main gate 1	1	3	Good
2	Main gate 2	1	3	Good
3	Main gate 3	1	3	Repairement Process
4	Main gate 4	1	3	Repairement Process
5	Main gate 5	1	3	Repairement Process
6	Small gate	20		Good and Not Good

Polder Liang, namely Martapura River, Cascade River Right, and Bincau River. Therefore, when there is a local rain for a few days, Liang Polder channels cannot accommodate the flow of water coming in, the area will be flooded high enough. Topography is relatively flat and evenly distributed rainfall which felt in the upstream areas causing the rise of water level to equal of the elevation of Liang Polder dikes. Rising river water resulting in water elevation from the river into the polder area of agricultural land causes flooded for a considerable time.

Figure 6 shows the rivers around Liang Polder. From the figure, it can be seen that Liang Polder serves as outlet.

Complementary Buildings

1) Dikes

Liang Polder is surrounded by long dikes of about 17.5 kilometers. The main function of this dike is to protect the polder areas and isolate the effect of the water from outside Liang Polder. The conditions of the dikes are good because they are paved road as shown in the next Fig. 7.



Fig. 6 Liang Polder serves as outlet



Fig. 7 Dikes as paved road in Liang Polder

2) Irrigation

Liang Polder Irrigation in the area is a channel with a diameter of ± 1 meter which serves to irrigate the rice fields during the growing season until harvest. Irrigation is derived from irrigation canals of Riam Kanan Reservoir that can be operated with the gate control as shown in Fig. 8.

3) Drainage

Here is a drainage culvert with dimensions of 50 cm which serves as a means of disposal without control open and close if there is excess water from the area outside the Liang Polder. Untreated drainage conditions shown in Fig. 9.



Fig. 8 Irrigation channel in Polder Liang



Fig. 9 The channels are not maintained



Fig. 10 Cages of fish Farming under the bridge

4) Bridges

Bridges are structures which are built to connect the two roads that cut off because of the river. There are 3 bridges in Polder Liang area. In Fig. 10, many cages are used for fish farming in the river.

Hydrological Analysis

When there is no correlation between adjacent observations, the output of a hydrologic system is treated as stochastic, space-independent and time-independent. This type of treatment is appropriate for observations of extreme hydrologic events, such as floods or droughts and for hydrologic data averaged over long time intervals, such as annual precipitation (Chow et al. 1988).

Rainfall Characteristics

Rainfall characteristics in an area can be only well defined if long term rainfall data is available. It means that the annual maxima data is suitable enough for extreme value distribution analysis (Gautama 1997). In most cases, it is difficult to meet this condition.

Rainfall is considered as a random event and it varies geographically, temporally and seasonally. Methods of statistical analysis have been developed to identify rainfall characteristics (Gautama 1997). Liang Polder should be properly designed to handle extreme rainfall events during its design life.

Rainfall Data Series

There are two types of data series for extreme events. A partial duration series is a series of data which are selected so that their magnitude is greater than predefined base value. An annual series data takes one highest or lowest data from each of a record (Chow et al. 1983).

According to Triatmodjo (2009), partial duration series (also called Peak Over Threshold, POT) is used if the available data is less than 10 consecutive years. Therefore, in one year there are more than one data used in the analysis. In each year, second to fifth highest data can be chosen for the analysis. For annual maximum series, the available data is more than 10 consecutive years. By choosing one maximum data for each year, the

second highest data which probably higher than maximum data from other year will not be considered.

In this study, the available rainfall data from Pengaron Station, Station Martapura, Aranio Station, Station Simpang Empat, and Matraman Station were just erected from 2007 to 2011 (uncomplete data). Consequently, only small number of annual maxima data is available. In this case, the only analysis which can be done is using partial duration data series. Then, the calculation of the mean areal rainfall are presented in Table 3.

For Maximum Rainfall Analysis, statistical parameters required for the calculation were the middle value, standard deviation and coefficient of skewness. Gumbel and Log Pearson Type III distribution were used to describe the probability of annual maximum flood peaks, since these two methods are recommended (de Laat and Savenije 2002). The Log-Pearson Type III was developed as a method of fitting a curve to data. Its use is justified by the fact that it has been found to yield good results in many application, particularly for flood peak data (Chow et al. 1983).

Testing the probability distribution is intended to determine whether the selected probability distribution equation can represent the statistical distribution of the data sample analyzed. There are two methods of testing the probability distribution, the method of Chi-Square (Chow et al. 1983) and Kolmogorov-Smirnov method.

The results of Rainfall Distribution Analysis and the probability distribution test can be seen in Table 4, Table 5 and Table 6 respectively.

Based on Table 4, 5 and 6 the best distribution is Log Person type III distribution. Therefore, in the calculation of rainfall frequency analysis, Log Pearson type III probability distribution was used.

Table 3 The calculation of mean areal rainfall using partial duration data series

No	Data on average daily rain (mm)	No	Data on average daily rain (mm)
1	71.50	11	42.00
2	71.00	12	41.83
3	63.00	13	41.00
4	60.33	14	39.67
5	58.95	15	39.43
6	58.22	16	37.50
7	56.83	17	37.00
8	50.75	18	35.63
9	48.93	19	35.50
10	48.83	20	35.3

Table 4 The results of rainfall distribution analysis

Return Periods T (years)	Gumbel Distribution (mm)	Log Pearson type III Distribution (mm)
2	46.9	46.7
5	59.7	57.6
10	68.1	64.8
20	76.3	70.8
25	78.8	73.9
50	86.8	80.8
100	94.6	87.8

Table 5 The results of the Chi-square test for various methods of probability distributions

Probability Distribution	χ^2	χ^2_{cr}	Subscribe
Gumbel	29.8	7.8	Not Allowed
Log Pearson Type III	2.8	7.8	Allowed

Table 6 The Results of the Smirnov-Kolmogorov test for various methods of probability distributions

Probability Distribution	ΔP	ΔP_{kritis}	Subscribe
		0.05	
Gumbel	1.67	0.29	Not Allowed
Log Pearson Type III	0.13	0.29	Allowed

Rainfall Intensity

Available rainfall data were daily rainfall data. Which can be determined by Mononobe Formula (Suripin 2004). The correlation between intensity of short time rainfall duration and 24-hour rainfall follows the Mononobe's equation (Sosrodarsono and Takeda 1983).

$$I_t = \frac{R_{24}}{24} \left(\frac{24}{t} \right)^m \tag{1}$$

Where I_t is rainfall intensity in mm/hour for duration t , R_{24} is 24-hour rainfall and m is 2/3.

Table 7 presents the calculation of the Design Rainfall Intensity for each river in the Liang Polder with Mononobe's approximation to determine rainfall intensities.

Intensity Duration Frequency (IDF) Curve of daily rainfall data at Liang Polder area for 10 years return periods can be seen in Fig. 11 as shown below:

Table 7 The rainfall intensity in Liang Polder

No	Name of river	X_t (mm)	t_c (hour)	I (mm/hour)
1	River Liang	64.8	8.7	7.4
2	River Besar	64.8	0.6	30.8
3	River Arpat	64.8	1.4	53.5
4	River Antasan	64.8	0.2	68.9
5	River Antasan-Ambawang	64.8	2.0	32.0
6	River Baku	64.8	0.2	57.5

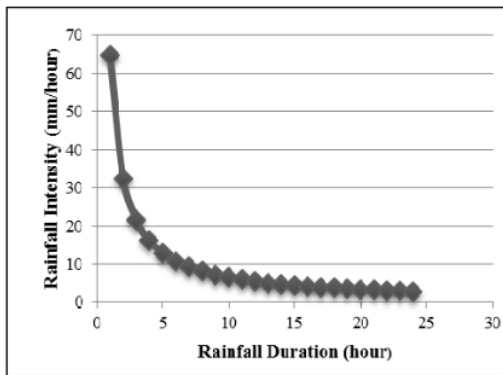


Fig. 11 IDF Curve for 10-years return periods

Design Discharge Analysis

Rational Method was used to calculate the discharge in this study. Rational Method can be used to calculate the peak discharge of the river with limited drainage.

In Liang Polder area that has relatively flat topography, the runoff coefficient of 0.4 was taken. The River discharge for Liang Polder was calculated using Manning Formula:

$$Q = \frac{1}{n} R^{2/3} S^{1/2} A \quad (2)$$

where Q is discharge in m³/s with hydraulic radius R, S is slope and A is area in m².

Table 8 shows the comparison of Design Discharge (Q_D) and River Discharge (Q_S). River Discharge (Q_S) was measured in the field study.

From the comparison, it can be concluded that the cross-sections of Rivers in Liang Polder were unable to accommodate local rainfall occurred. Then the next step is to calculate the economical cross-section channels so that they can accommodate the design discharge which is presented in Table 9.

Table 8 The comparison of design discharge (Q_D) and river discharge (Q_S)

River	Q_D (m ³ /s)	Q_S (m ³ /s)	Conclusion
River Liang	6.6	0.8	Not being able to accommodate
River Baku	16.0	13.2	Not being able to accommodate
River Besar	8.7	6.2	Not being able to accommodate
River Arpat	29.3	1.4	Not being able to accommodate
River Ambawang	18.5	0.6	Not being able to accommodate
River Antasan	28.5	13.0	Not being able to accommodate

Table 9 Calculation of economical cross-section with manning equation

River	L (m)	Q_T (m ³ /s)	S	h (m)	B (m)
River Liang	6843.6	6.6	0.000146	2.8	3.2
River Baku	309.3	16.0	0.003233	2.2	2.5
River Besar	696.7	8.7	0.001435	2.0	2.3
River Arpat	1354.3	29.3	0.000738	3.6	4.1
River Ambawang	1936.9	18.5	0.000516	3.2	3.7
River Antasan	244.2	28.5	0.004095	2.6	3.0

As conclusion, to be able to accommodate local rainfall which resulted to design discharge of Liang Polder, the channels must have a cross-sectional size as seen in Table 9.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the survey results and the identification also the analysis which have been conducted in Liang Polder, it can be concluded as follows:

1. Polder Liang is a semi-technical polder because water is still operated manually through the door that is not equipped with a flow meter and the carrier channel and the drainage channels are not completely separated. All primary floodgates on Liang Polder serve as the outlet from the Polder. In addition, not all of surrounding dikes elevation in Liang Polder are higher than in the

polder area , but there is still a levee on the river side elevation namely Bincau which is parallel with elevation in the Liang Polder thus affected the flow of the channel.

2. Given the original polder land in a swampy bog, which is not equipped with a drainage system to drain the stagnant water in the polder, land use for agriculture can only be done during the dry season, when water in the polder has been relatively shallow. While the analysis is based on the ability of flood retention in Liang Polder, It is not able to accommodate the discharge of rainfall due to local rainfall. This condition is in accordance with the existing conditions in the field that is still going on until the flood water level due to overflow into the embankment of the incoming flow of natural channel around the Polder.

3. Currently, Liang Polder cannot serve its function due to lack of optimization and maintenance actions are performed , considering the condition of the channel in the Liang Polder and condition of the building is 40 % are in damage condition . So the optimization actions that can be done is to repair and dredge the channel to be able to drain naturally from the water entry in the polder. While the preventive measures that can be done for maintenance Liang Polder is a routine maintenance on all buildings in the area of Liang Polder.

Recommendations

1. Polder Liang under the supervision of the Department of Public Works should have complete data on the existing condition of the Polder that can be fully utilized.

2. Based on the results of the inventory and identification Polder Liang, hence the need for further research in Polder Liang in order can function more optimally.

3. Appointment of delegates of the local community by the relevant agencies to be given a briefing in maintaining and controlling the floodgates and encourage local communities to raise awareness to keep the channel in the Polder Liang

4. Need to increase the activity and function of the area under Polder farmer groups in order to increase agricultural output to improve people's prosperity in neighboring area of the Polder.

5. Land use around the dike should be controlled as tightly as possible. At least, along the banks of the river and canal embankments should be free of buildings and settlements illegal because if flood happens it will inundate the region.

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