FINAL REPORT

REGIONAL STUDY ON THE DEVELOPMENT OF EFFECTIVE WATER MANAGEMENT INSTITUTIONS:

A CASE STUDY OF THE BANG PAKONG RIVER BASIN THAILAND

PREPARED BY

Associate Professor Virapol Taesombut, Ph.D.
And His Staffs

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เลขที่ 979/17-21 ถนนพหลโยธิน แขวงสามเสนใน
เขตพญาไท กรุงเทพฯ 10400
โทร.298-0455 โทรสาร 298-0476
Home page : http://www.trf.or.th
E-mail : trf-info@trf.or.th

CONTACT: RDG45-3-0003

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THAILAND

Researcher	Offices
1. Virapol Taesombut	Kasetsart University
2. Kobkiat Pongput	Kasetsart University
3. Sukontha Aekaraj	Water Resources Committee Office
4. Sivapong Kaysavawong	Water Resources Committee Office
5. Eric Biltonen	International Water Management Institute-South East Asia

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รายงานสรุปสำหรับผู้บริหาร

รายงานฉบับนี้จัดขึ้นตามโครงการ Development of Effective Water Management Institutes ในประเทศไทย ซึ่งมีพื้นที่ศึกษาคือ ลุ่มน้ำบางปะกง และลุ่มน้ำแม่กลอง โดยรายงานฉบับนี้เป็นผลการศึกษาของลุ่มน้ำบางปะกง

รายงานฉบับนี้ได้รวมการวิเคราะห์ 3 ส่วนเข้าด้วยกัน คือ การวิเคราะห์บัญชีน้ำ การวิเคราะห์เศรษฐกิจ-สังคม และการวิเคราะห์องค์กร โดยมีเป้าหมายเพื่อพัฒนาการเชื่อมโยงระหว่างองค์ประกอบทั้งสามส่วนนี้เพื่อให้การออกแบบและจัดตั้งองค์กรจัดการน้ำเป็นไปอย่างมีประสิทธิภาพ

บัญชีน้ำ

บัญชีน้ำเป็นกรอบที่ใช้อธิบายการใช้น้ำ และผลผลิตที่ได้จากน้ำภายในพื้นที่ที่พิจารณา การวิเคราะห์จะอยู่บนพื้นฐานของสมดุลน้ำ โดยพิจารณาจากปริมาณน้ำที่ไหลเข้าและไหลออกจากขอบเขตการใช้น้ำที่พิจารณา เช่น ลุ่มน้ำ ลุ่มน้ำย่อย หรือพื้นที่ระดับย่อยอื่นๆ การศึกษานี้ได้แบ่งลุ่มน้ำบางปะกงออกเป็น 7 ลุ่มน้ำย่อย คือ ลุ่มน้ำคลองพระสะทึง คลองพระปรง แม่น้ำหนุมาน ปราจีนบุรีสายหลัก นครนายก คลองหลวง และบางปะกงสายหลักรวมกับท่าลาด ซึ่งการแบ่งนี้จะใช้รวมไปถึงในการวิเคราะห์เศรษฐกิจ-สังคมด้วย เพื่อเปรียบเทียบและแสดงการเชื่อมโยงองค์ประกอบทั้งสองนี้

การวิเคราะห์บัญชีน้ำจะทำเป็นรายฤดูและรายปี โดยเลือกปี ค.ศ. 1994, 1995 และ1996 เป็นปีตัวแทนสำหรับปีฝนปกติ ปีฝนมาก และปีฝนแล้ง

จากการวิเคราะห์พบว่า ปริมาณน้ำเข้าทั้งหมดในฤดูฝนมีปริมาณที่สูงกว่าปริมาณน้ำที่หมดไป แต่ในฤดูแล้งจะน้อยกว่าปริมาณน้ำที่หมดไป อัตราส่วนของปริมาณน้ำที่หมดไปต่อปริมาณน้ำเข้าทั้งหมดมีค่าลดลงจากเหนือน้ำลงสู่ท้ายน้ำ อัตราส่วนของปริมาณน้ำที่หมดไปต่อปริมาณน้ำที่ใช้งานได้มีค่ามากกว่าร้อยละ 90 แสดงว่าปริมาณน้ำที่สามารถใช้งานได้ส่วนใหญ่ถูกใช้จนหมดไป ซึ่งการใช้หมดไปนี้รวมถึง การระเหยในลำน้ำ การคายระเหยในพื้นที่ไดพรวน ปริมาณน้ำที่ไหลลงทะเลหรือพื้นที่อื่นซึ่งไม่คุ้มค่าทางเศรษฐกิจในการนำน้ำกลับมาใช้ใหม่ ปริมาณน้ำที่เกินความต้องการ และปริมาณน้ำที่ถูกควบรวมอยู่ในผลิตภัณฑ์ต่างๆ ซึ่ง

ปริมาณน้ำประมาณร้อยละ 70 ของปริมาณน้ำที่สามารถใช้งานได้หรือร้อยละ 80 ของปริมาณน้ำที่หมดไป ถูกนำไปใช้ในกระบวนการ ซึ่งเป็นกิจกรรมที่มนุษย์ตั้งใจ (Intend to use) ได้แก่ การคายระเหย การใช้น้ำเพื่อการอุปโภคและบริโภค และการใช้น้ำอุตสาหกรรม และสุดท้ายจากการวิเคราะห์พบว่า ประสิทธิภาพของลุ่มน้ำมีค่าประมาณร้อยละ 90 ซึ่งแสดงให้เห็นว่ามีการใช้น้ำในลุ่มน้ำอย่างมีประสิทธิภาพ

จากผลการวิเคราะห์บัญชีน้ำ ได้เสนอแนะว่า การพัฒนาลุ่มน้ำควรดำเนินการในด้านการจัดการน้ำ เช่น การปรับปรุงปฏิทินเพาะปลูกและแผนการเพาะปลูก การปรับปรุงคุณภาพน้ำ การลดการใช้น้ำที่ไม่ต้องการ หรือวิธีการอื่นที่จะเพิ่มผลผลิตจากการใช้น้ำ เนื่องจากลุ่มน้ำมีศักยภาพและความคุ้มค่าทางเศรษฐกิจในการก่อสร้างอาคารพื้นฐานในลุ่มน้ำต่ำ จึงไม่คุ้มค่าต่อการลงทุนสร้างอาคารพื้นฐาน

การวิเคราะห์เศรษฐกิจ-สังคม

การวิเคราะห์เศรษฐกิจสังคม มีจุดมุ่งหมายเพื่อรวบรวมลักษณะทั่วไปทางเศรษฐกิจสังคมของลุ่มน้ำบางปะกง และประเมินสมรรถภาพของระบบชลประทาน ข้อมูลในการศึกษาได้รวบรวมตามพื้นที่ที่ได้แบ่งไว้ในการวิเคราะห์บัญชีน้ำ การวิเคราะห์จะเน้นที่ความยากจนภายในลุ่มน้ำ และผลกระทบที่มีต่อการจัดการน้ำอย่างมีประสิทธิภาพภายในลุ่มน้ำ

จากการวิเคราะห์พบว่า ความยากจนในชนบทจะหนาแน่นใน 2 พื้นที่คือ พื้นที่ลุ่มน้ำคลองพระสะทึง และคลองพระปรง แต่อย่างไรก็ตาม ยังไม่มีข้อมูลที่ชัดเจนที่แสดงความสัมพันธ์ระหว่างอัตราความยากจนและร้อยละของพื้นที่การชลประทาน อัตราความยากจนในชนบทมีค่าอยู่ระหว่างร้อยละ48 ในลุ่มน้ำคลองหลวง และร้อยละ 85 ในลุ่มน้ำแม่น้ำหนุมาน โดยการแบ่งอ้างอิงจากเส้นแบ่งชั้นความยากจนของ กชช2ค. และที่น่าสนใจคือ ประชากรในภาคเกษตรมีเพียงส่วนน้อยเท่านั้นที่ยากจน ประมาณร้อยละ21.6 ซึ่งน้อยกว่าในลุ่มน้ำแม่กลองซึ่งมีมากถึงร้อยละ 63 ของประชากรทั้งหมด ปัจจัยอื่นๆ ที่พิจารณา ได้แก่ ความสัมพันธ์ของความยากจนของการเกษตรกรรม ซึ่งประกอบด้วย เส้นทางสู่ตลาด ระดับของตลาดท้องถิ่น และความยั่งยืนของพื้นที่เกษตรกรรม

อิทธิพลต่อกระบวนการกำหนดนโยบายระหว่างผู้ใช้น้ำทั้งหมด จะมีค่าต่ำมาก สำหรับเกษตรกร ผู้ที่ยากจน และเกษตรกรนอกพื้นที่ชลประทาน แต่อย่างไรก็ตาม น้ำเกี่ยวข้องกับกลุ่มผู้ใช้น้ำจำนวนมาก ดังนั้นจึงจำเป็นต้องมีการระบุถึงความไม่สมดุลระหว่างอิทธิพลในการกำหนดนโยบายและการใช้น้ำชลประทาน จากการขาดแคลนน้ำที่เพิ่มมากขึ้น ศักยภาพ

แสดงให้เห็นว่า ถ้าผู้ใช้น้ำที่มีอำนาจต่อรองสูงมีจำนวนมากขึ้น จะแบ่งน้ำปริมาณมากจากกลุ่มผู้ใช้น้ำที่มีอำนาจต่อรองต่ำ ซึ่งสิ่งนี้จะซ้ำเติมปัญหาความยากจนภายในลุ่มน้ำ

รายได้ต่อไร่ของข้าวจะคงที่ตลอดลุ่มน้ำ ยกเว้นในลุ่มน้ำย่อยคลองหลวงซึ่งมีแน้วโน้มที่จะเพิ่มขึ้น สิ่งนี้สะท้อนให้เห็นถึงการเพิ่มผลผลิตของข้าวในลุ่มน้ำคลองหลวง จากผลการวิเคราะห์ พบว่า ผลผลิตทางการเกษตรจะค่อนข้างต่ำในพื้นที่ด้านหนือน้ำ แต่อย่างไรก็ตามยังคงต้องการข้อมูลเพิ่มเติมในการสรุปอย่างชัดเจนต่อไป ในพื้นที่ด้านเหนือน้ำมีแนวโน้มของพื้นที่ปลูกข้าวโพดเลี้ยงสัตว์และมันสำปะหลังเพิ่มขึ้น แต่ข้าวก็ยังคงเป็นพืชหลัก

จากการวิเคราะห์เศรษฐกิจสังคม พบว่าในปัจจุบัน มีข้อขัดแย้งและการประนีประนอมระหว่างผู้ใช้น้ำเกิดขึ้นเป็นจำนวนมาก ส่วนสำคัญของการประนีประนอมคือ เริ่มแรกจะเกี่ยวข้องกับผู้รับน้ำชลประทานและกลุ่มใช้น้ำอื่นๆ หรือขัดแย้งระหว่างกลุ่มรับน้ำชลประทาน เนื่องจากผู้รับน้ำชลประทานมีบทบาทในการตัดสินใจน้อย และมักจะเป็นผู้เสียเปรียบในการต่อรอง โดยเฉพาะอย่างยิ่ง เนื่องจากกลไกการตกลงในข้อยัดแย้งยังคงอ่อนแอหรือไม่ได้รับการพัฒนา ดังนั้น ภายในกลุ่มรับน้ำชลประทาน กลุ่มที่ยากจนมักจะได้รับผลผลิตที่ไม่ค่อยดี

ท้ายที่สุด ในการวิเคราะห์สมรรถภาพชลประทานของระบบชลประทานในลุ่มน้ำบางปะกง ลักษณะที่เด่นที่สุดของการวิเคราะห์คือ เกณฑ์การช่วยเหลือตัวเองทางการเงินมีค่าเท่ากับศูนย์ ซึ่งเป็นผลโดยตรงจากให้น้ำชลประทานในลักษณะสินค้าได้เปล่า สิ่งนี้ก่อให้เกิดสถานการณ์ในการจัดการระบบชลประทานขึ้นอยู่กับเงินทุนจากรัฐบาล จากความไม่มีอิสระทางด้านการเงิน ระบบชลประทานจึงขึ้นอยู่กับรัฐบาลและมีความอ่อนแอในการตัดสินจัดการน้ำ ซึ่งทำให้ระบบไม่ได้ให้ผลประโยชน์ที่ดีที่สุด นอกจากนี้การวิเคราะห์ยังมีลักษณะเด่นอื่นๆ คือ ดัชนีปริมาณน้ำต้นทุนสัมพัทธ์มีค่ามากกว่าหนึ่ง ในขณะที่ดัชนีปริมาณน้ำต้นทุนสำหรับการชลประทานสัมพัทธ์มีค่าติดลบ ดัชนีปริมาณน้ำต้นทุนที่มากกว่าหนึ่ง เป็นผลมาจากปริมาณน้ำฝนที่มากกว่าความต้องการใช้น้ำของพืช ดังนั้นจึงไม่น่าเกิดปัญหาการขาดแคลนน้ำ หากปัญหาการขาดแคลนน้ำเกิดขึ้นอย่างรุนแรง การเพิ่มการเก็บกักน้ำจะเป็นการพัฒนาที่จำเป็นอย่างยิ่ง

การวิเคราะห์องค์กร

การวิเคราะห์องค์กร มีวัตถุประสงค์เพื่อ แสดงโครงสร้างขององค์กรการจัดการทรัพยากรน้ำ ในลุ่มน้ำบางปะกง ในสภาวะปัจจุบัน มีการพัฒนาองค์กรในระดับท้องถิ่นและลุ่มน้ำ

สำหรับการจัดการทรัพยากรน้ำเพียงเล็กน้อย ส่วนหนึ่งเกิดมาจากการขาดความเข้าใจในเรื่องกฎหมายทรัพยากรน้ำในระดับชาติ และเกิดจากมีตัวแทนหลายฝ่ายของรัฐบาลเข้ามาทำหน้าที่ดูแลการจัดการทรัพยากรน้ำ ในเดือนตุลาคม พ.ศ. 2545 มีการจัดวางนโยบายของรัฐบาลใหม่ และจากเหตุการณ์ดังกล่าว กรมทรัพยากรน้ำจะต้องถูกย้ายจากกระทรวงเกษตรและสหกรณ์ไปอยู่ที่กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม

ในขณะที่มีการวางแนวคิดทั่วไปสำหรับการจัดการน้ำอย่างมีประสิทธิภาพ เช่น การจัดการลุ่มน้ำ และการจัดตั้งองค์กรเกษตรกร และเริ่มใช้แนวคิดดังกล่าว แต่อาคารชลประทานที่มีอยู่กลับขาดประสิทธิภาพที่จะตอบสนองแนวคิดการจัดการดังกล่าว หลักแนวทางในการจัดการลุ่มน้ำที่ออกโดยรัฐบาล จะเกี่ยวข้องกับ การแก้ไขปัญหาอย่างมีประสิทธิภาพ ความยุติธรรมในการจัดสรรน้ำ และการมีส่วนร่วมในกระบวนจัดการน้ำ การจัดตั้งองค์กรจัดการทรัพยากรน้ำในปัจจุบันมีความเหมาะสมที่จะตอบสนองแนวคิดดังกล่าว

การจัดตั้งองค์กรจัดการทรัพยากรน้ำในประเทศไทย ถูกกำหนดโดยพระราชบัญญัติซึ่งออกโดยสำนักนายกรัฐมนตรี ซึ่งเป็นหน่วยงานสูงสุดในประเทศ ในการจัดการทรัพยากรน้ำ หน่วยงานดังกล่าวคือ สำนักงานคณะกรรมการทรัพยากรน้ำแห่งชาติ (Office of the National Water Resource Committee, ONWRC) มีหน้าที่รับผิดชอบประสานงาน กำหนดนโยบาย และกฎหมายในการจัดการทรัพยากรน้ำ รวมถึงติดตามผลการดำเนินงานขององค์กรจัดการทรัพยากรน้ำในลุ่มน้ำ โดยองค์กรจัดการน้ำในระดับลุ่มน้ำตั้งขึ้นมาเพื่อกระจายการจัดการและพัฒนาทรัพยากรน้ำจากส่วนกลาง และในปี พ.ศ. 2544 ONWRC ได้จัดตั้งคณะกรรมการจัดการลุ่มน้ำบางปะกง เพื่อประสานงานการจัดการและกฎหมายทรัพยากรน้ำในลุ่มน้ำบางปะกง การวิเคราะห์องค์กรได้แสดงให้เห็นถึง ความยุ่งยากในการจัดตั้งองค์กรให้สามารถทำหน้าที่ได้อย่างสมบูรณ์ แต่ปัญหาที่สำคัญคือการขาดข้อตกลงในการคัดเลือกคณะกรรมการ ยิ่งไปกว่านั้น รายชื่อคณะกรรมการที่มีอยู่ ก็ไม่ครอบคลุมกลุ่มผู้มีส่วนได้เสีย

ในขณะที่ความต้องการการพัฒนาและปรับปรุงของหลายฝ่ายจะอยู่ในวิสัยทัศน์ด้านน้ำแห่งชาติ แต่ก็ยังคงมีช่องว่างในการจัดการอยู่ ร่างกฎหมายเรื่องน้ำจะเกี่ยวข้องกับการเรียกร้องจัดตั้งคณะกรรมการลุ่มน้ำและกระบวนการในการแก้ปัญหา แต่ก็ไม่สามารถตอบสนองได้ทั้งในเรื่ององค์กรลุ่มน้ำและการแก้ปัญหาหน่วยงานที่แท้จริงที่รับผิดชอบในการแก้ปัญหา

กฎหมายที่มีอยู่ที่เกี่ยวข้องกับการจัดการทรัพยากรน้ำ ส่วนใหญ่จะล้าสมัยและตั้งอยู่บนสถานการณ์ที่ไม่เกิดขึ้นอีกแล้ว ดังตัวอย่าง กฎหมายมาตราที่ 1304 ของกฎหมายแพ่งและพาณิชย์ ระบุว่า ทางน้ำเป็นของสาธารณะ และรัฐไม่สามารถกีดกันผู้หนึ่งผู้ใดในการนำน้ำไป

ใช้งาน ซึ่งกฎหมายฉบับนี้ได้กำหนดขอบเขตการนำน้ำไปใช้งานบนพื้นฐานของการความต้องการน้ำอย่างสมเหตุสมผลของผู้ใช้น้ำแต่ละราย พระราชบัญญัติชลประทานหลวง พ.ศ. 2485 ได้กล่าวถึงคลองชลประทาน ซึ่งกำหนดขอบเขตของค่าธรรมเนียมชลประทานไว้ที่ 5 บาท ต่อไร่ต่อปี ถึงแม้จะมีอัตราที่ต่ำ แต่ค่าธรรมเนียมนี้ก็ยังไม่ได้มีการจัดเก็บในลุ่มน้ำ สิ่งนี้ก่อให้เกิดปัญหา เนื่องจากการจัดการชลประทานจะขึ้นอยู่กับเงินทุนจากรัฐบาล

ในขณะที่มีการปรับปรุงองค์กรตามการเปลี่ยนแปลงโครงสร้างของผู้บริหาร แต่ก็ยังคงมีข้อบกพร่องในเรื่องความสามารถในการจัดการขององค์กรที่จัดตั้งขึ้นมาใหม่ เช่น คณะกรรมการลุ่มน้ำ องค์การบริหารส่วนตำบล ฯลฯ องค์กรเหล่านี้ต้องการเสริมสร้างความสามารถอย่างยั่งยืน ในการสร้างประสบการณ์ และเรียนรู้ที่จะควบคุมให้มีการจัดการทรัพยากรน้ำอย่างมีประสิทธิภาพ ซึ่งสิ่งเหล่านี้จะมีความสำคัญอย่างยิ่ง ในการจัดตั้งองค์กรลุ่มน้ำใหม่ๆ

เขื่อนผันน้ำบางปะกงดำเนินการโดยกรมชลประทาน มีความไม่สอดคล้องในวัตถุประสงค์หรือความต้องการใช้น้ำ ปัญหาใหญ่ที่พบคือ การจัดสรรน้ำให้แก่ผู้ใช้น้ำด้านเหนือเขื่อนและท้ายเขื่อน และปัญหาระหว่างการเก็บกักน้ำของเขื่อนผันน้ำกับสิ่งแวดล้อม ตามแผนเดิมมีการเรียกร้องให้ก่อสร้างอ่างเก็บน้ำทางด้านเหนือน้ำจำนวน 12 แห่ง แต่นักสิ่งแวดล้อมยังคงต่อต้านไม่ให้มีการสร้างเขื่อนเหล่านี้ ซึ่งทำให้เขื่อนผันน้ำไม่มีประสิทธิภาพในการดำเนินงานอย่างเต็มที่ ดังนั้นองค์กรลุ่มน้ำที่จัดตั้งขึ้นใหม่ จึงต้องเผชิญหน้ากับการแก้ปัญหาที่เกิดขึ้นนี้

ข้อเสนอแนะและสรุป

จากหัวข้อที่ผ่านมาซึ่งได้สรุปเนื้อหาจากการวิเคราะห์ทั้ง 3 ส่วน การวิเคราะห์บัญชีน้ำได้แสดงให้เห็นถึงสถานการณ์ปัจจุบันในลุ่มน้ำว่า น้ำยังคงเพียงพอ หากมองในภาพรวมทั้งปี แต่สถานการณ์ดังกล่าวอาจเปลี่ยนไปตามสถานการณ์ในอนาคต เช่น กรณีที่เพิ่มการใช้น้ำชลประทานของอ้อย และการเพิ่มการผันน้ำลงสู่กรุงเทพมหานคร ซึ่งในทั้งสองกรณีจะทำให้เกิดสถานการณ์ที่น้ำไม่พอเพียงต่อความต้องการ

การวิเคราะห์เศรษฐกิจสังคมและการประเมินสมรรถนะการชลประทานแสดงให้เห็นถึงบทบาทของผู้รับน้ำชลประทานมีต่อการจัดการน้ำในลุ่มน้ำ โดยเฉพาะการเกษตรกรรมที่มีอำนาจต่อรองในลุ่มน้ำ ทั้งในด้านการประกอบอาชีพและเป็นตัวแปรที่บรรเทาความยากจน เกษตรกรทั่วไปจะไม่มีอิทธิพลต่อการกำหนดนโยบายและกระบวนการตัดสินใจ นอกจากนี้

การวิเคราะห์ยังได้แสดงให้เห็นว่า เกษตรกรในลุ่มน้ำกำลังพบกับปัญหาราคาข้าวลดลง ซึ่งส่งผลให้ความยากจนเพิ่มขึ้นในพื้นที่ด้านเหนือน้ำ และมีรายรับที่ไม่ยุติธรรมเพิ่มขึ้นในลุ่มน้ำ

การทำนากุ้งกำลังเป็นเกษตรกรรมที่นิยม เนื่องจากรายได้ต่อไร่มีอัตราสูงกว่าพืชอื่นๆ แต่อย่างไรก็ตามการทำนากุ้งเพิ่มขึ้นได้ส่งผลกระทบทางลบต่อระบบ เช่น การลดลงของผลผลิตในพื้นที่รอบๆ มลภาวะทางน้ำที่ปล่อยลงสู่ท้ายน้ำ การใช้น้ำที่เพิ่มสูงขึ้น และการดึงน้ำเข้าสระอย่างผิดกฎหมาย จึงจำเป็นที่จะต้องมีวิธีการที่มีประสิทธิภาพในการสร้างความสมดุลของความต้องการน้ำของผู้มีส่วนได้เสีย ซึ่งเคร่งครัดต่อนโยบาย กระตุ้นให้เกิดแรงจูงใจที่หยุดผลกระทบจากการทำนากุ้ง และชดเชยค่าเสียหายให้แก่ผู้ที่ได้รับผลกระทบ

การวิเคราะห์องค์กร แสดงให้เห็นว่า มีการพัฒนาในเชิงบวกในการจัดการลุ่มน้ำที่มีประสิทธิภาพ โดยเฉพาะอย่างยิ่ง การตระหนักถึงความต้องการในการจัดตั้งองค์กรจัดการน้ำในระดับลุ่มน้ำ ความต้องการในการจัดตั้งองค์กรเกษตรกร เพื่อเป็นตัวแทนของเกษตรกร และความต้องการในการประสานงานการจัดการทรัพยากรน้ำระหว่างตัวแทนจากหลายๆ ส่วนที่ดีขึ้น อย่างไรก็ตาม หลายกระบวนการจะต้องตระหนักถึงเป้าหมายสูงสุดจากการเปลี่ยนแปลงครั้งนี้ ซึ่งก่อนหน้านั้น จะต้องออกพระราชบัญญัติกฎหมายน้ำแห่งชาติที่มีประสิทธิภาพ และกินความกว้าง กฎหมายต้องชัดเจน ไม่ใช่กล่าวถึงเพียงหน้าที่และความรับผิดชอบของหน่วยงานต่างๆ แต่จะต้องชัดเจนถึงอำนาจของแต่ละหน่วยงานใช้หน้าที่หรือบังคับใช้กฎหมาย ข้อบกพร่องที่พบในระหว่างการสำรวจภาคสนาม คือ ไม่มีความมชัดเจนว่าผู้ใดจะเป็นผู้รับผิดชอบในการบังคับใช้นโยบาย หรือขาดมาตรฐานในการทำงาน กลุ่มจัดการควรจะมีตัวแทนระดับสูงจากรัฐบาลเข้าร่วมด้วย เพื่อดูแลข้อกฎหมายและอำนาจ เพื่อได้ผลตามที่ต้องการ

โดยทั่วไป ฐานะของเกษตรกรในกระบวนการตัดสินใจต้องมีการเสริมสร้างความมั่นคง โดยเกษตรกรจะต้องมีบทบาทที่เข้มแข็งในการกำหนดนโยบาย ซึ่งสิ่งนี้จะเกี่ยวข้องกับกลุ่มเกษตรกรขนาดใหญ่ เช่น สหพันธ์กลุ่มผู้ใช้น้ำ และกลุ่มตัวแทนหรือสมาชิกที่มีระดับการตัดสินใจที่สูงขึ้น

การตระหนักถึงความต้องการการจัดการที่เข้มแข้งของท้องถิ่น จะทำให้มีการจัดตั้งคณะกรรมการลุ่มน้ำ ซึ่งเป็นการเปลี่ยนพื้นฐานในการประสานงานที่ดีขึ้นระหว่างหน่วยงานต่างๆ และตัวแทนของผู้ที่มีส่วนได้เสีย หลักสำคัญในการจัดการทรัพยากรน้ำอย่างมีประสิทธิภาพในลุ่มน้ำบางปะกง คือ

1) การปรับปรุงการสื่อสารและประสานงานระหว่างตัวแทนจากหลายฝ่าย และผู้มีส่วนได้เสีย

2) การบังคับใช้นโยบายและกฎหมายอย่างมีประสิทธิภาพ

3) การจัดตั้งองค์กรที่มีประสิทธิภาพ ซึ่งรับผิดชอบในเรื่องความต้องการของเกษตรกร และมีบทบาทในกระบวนการตัดสินใจ

4) การสร้างแรงจูงใจอย่างเป็นระบบในการควบคุม บังคับ และชดเชยสำหรับรูปแบบการใช้น้ำ

5) ความตระหนักและรับผิดชอบต่อความขาดแคลนน้ำที่เพิ่มขึ้น

รายงานฉบับนี้ได้สรุปงานวิจัย 3 ส่วนทั้ง 3 องค์ประกอบของการศึกษา เพื่อเชื่อมโยงองค์ประกอบทั้งสามเข้าด้วยกัน นอกจากนี้ยังมีข้อแนะนำเกี่ยวกับการพัฒนานโยบาย เพื่อให้เกิดองค์กรการจัดการทรัพยากรน้ำที่มีประสิทธิภาพ เพื่อจัดการน้ำในลุ่มน้ำบางปะกง

บทคัดย่อ

รหัสโครงการ : RDG4530003

ชื่อโครงการ : การพัฒนาองค์กรการจัดการน้ำ-กรณีศึกษาลุ่มน้ำบางปะกง

ชื่อนักวิจัย : วีระพล แต้สมบัติ[1], กอบเกียรติ ผ่องพุฒิ[1], สุคนธา แอคะรัฐ[2], ปวิช เกศวะวงษ์[2] และ Eric Biltonen[3]

Email address : kobkiat.p@ku.ac.th

ระยะเวลาโครงการ : กันยายน 2544 – พฤศจิกายน 2545

รายงานฉบับนี้เป็นผลการศึกษาของโครงการพัฒนาสถาบันการจัดการน้ำอย่างมีประสิทธิภาพในลุ่มน้ำบางปะกง โดยมีเป้าหมายเพื่อพัฒนาการเชื่อมโยงระหว่างองค์ประกอบ 3 ส่วน คือ การวิเคราะห์บัญชีน้ำ การวิเคราะห์เศรษฐกิจ-สังคม และการวิเคราะห์องค์กรเพื่อให้การออกแบบและจัดตั้งองค์กรจัดการน้ำเป็นไปอย่างมีประสิทธิภาพ

การวิเคราะห์บัญชีน้ำได้แสดงให้เห็นถึงสถานการณ์ปัจจุบันในลุ่มน้ำ ซึ่งหากมองในภาพรวมทั้งปี น้ำยังคงเพียงพอต่อความต้องการ แต่สถานการณ์ดังกล่าวอาจเปลี่ยนไปในอนาคต เช่นในกรณีที่เพิ่มการใช้น้ำชลประทานของอ้อย และการเพิ่มการผันน้ำลงสู่กรุงเทพมหานคร นอกจากนี้ยังพบว่า ลุ่มน้ำมีประสิทธิภาพการใช้น้ำมากถึงร้อยละ 90 ซึ่งแสดงให้เห็นว่ามีการใช้น้ำในลุ่มน้ำอย่างมีประสิทธิภาพ

การวิเคราะห์เศรษฐกิจ-สังคมและการประเมินสมรรถนะการชลประทานแสดงให้เห็นถึงบทบาทของผู้รับน้ำชลประทานมีต่อการจัดการน้ำในลุ่มน้ำ เกษตรกรทั่วไปจะไม่มีอิทธิพลต่อการกำหนดนโยบายและกระบวนการตัดสินใจ

การวิเคราะห์องค์กร แสดงให้เห็นถึงการก้าวย่างเชิงบวก เพื่อเข้าสู่การจัดการลุ่มน้ำอย่างมีประสิทธิภาพ โดยเฉพาะอย่างยิ่ง การตระหนักถึงความต้องการในการจัดตั้งองค์กรจัดการน้ำในระดับลุ่มน้ำ ความต้องการในการจัดตั้งองค์กรเกษตรกรเพื่อเป็นตัวแทนของเกษตรกร และความต้องการในการประสานงานการจัดการทรัพยากรน้ำที่ดีขึ้น ระหว่างตัวแทนจากหลายๆ ส่วน

คำสำคัญ: ลุ่มน้ำบางปะกง การวิเคราะห์บัญชีน้ำ การวิเคราะห์เศรษฐกิจสังคม การวิเคราะห์องค์กร การจัดการน้ำอย่างมีประสิทธิภาพ

[1]คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์, [2]กรมทรัพยากรน้ำ และ [3]Internation Water Management Institute-South East Asia

ABSTRACT

Project Code : RDG4530003

Project Title : Regional Study on the Development of Effective Water Management Institutions: A Case Study of the Bang Pakong River Basin

Investigators : Taesombut, V.[1], Pongput, K.[1], Aekaraj, S.[2], Kysavawong, P.[2] and Biltonen, E.[3]

Email address : kobkiat.p@ku.ac.th

Project Duration : September 2001–November 2002

This report is conducted for the "Development of Effective Water Management Institutions" in the Bang Pakong River Basin. The goal of this study was to identify linkages between these three components include water accounting analysis, a socio-economic analysis, and an institutional analysis, so as to better identify and design effective water management institutions.

The water accounting component indicated the current situation of the basin. Currently, water is still adequate on an annual basis, but this situation may reverse under a number of scenarios come to being in the future. Among these scenarios is increased irrigation by sugarcane growers and increased diversions to Bangkok. The basin efficiency of this basin is about 90%, it showed that this basin has high effective water consumption.

The Socio-Economic Analysis and Irrigation Performance Analysis highlighted the important role that irrigators play in water management of the basin. In particular, agriculture plays a significant role in the basin, both in terms of livelihoods and as a factor in poverty alleviation. Farmers in general are not very influential in the policy making and decision making process. They are, however, among the most vulnerable.

The Institutional Analysis section indicated that while many positive steps have been taken toward the more effective management of river basins. In particular, the recognition of the need for river basin organizations to manage water from the basin perspectives, the need to establish farmer organizations to represent farmers, and the need to better coordinate water resources management among the many diverse agencies.

Keyword: The Bang Pakong River Basin, Water Accounting Analysis, Socio-Economic Analysis, Institutional Analysis, Effective water Management

[1]Faculty of Engineering, Kasetsart University, [2]Water Resources Department, and [3]Internation Water Management Institute-South East Asia

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ACRONYMS

DEDP	Department of Energy Development and Promotion
DMR	Department of Mineral Resources
DPC	Department of Pollution Control
EGAT	Electricity Generating Authority of Thailand
GMKIP	Greater Mae Klong Irrigation Project
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
MOAC	Ministry of Agriculture and Cooperatives
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology and Environment
NESDB	National Economic and Social Development Board
NGO	Non-governmental Organization
NWRC	National Water Resources Committee
PHRD	Population and Human Resource Development
ONWRC	Office of the National Water Resources Committee
PIO	Provincial Irrigation Officer
PWA	Provincial Waterworks Authority
RBC	River Basin Committee
RID	Royal Irrigation Department
SRBC	Sub-River Basin Committees
TAO	Tambon (Sub-district) Administrative Organization
WUC	Water User Cooperative
WUO	Water User Organization

1 rai	=	0.16 ha
43 Baht	=	US$ 1

Chapter

1

Introduction and General Basin Description

The "Regional Study on Development of Effective Water Management Institutions" project was originally planned to be conducted in five countries: China, Indonesia, Nepal, Philippines, and Sri Lanka. In 2001 during a regional workshop held in Indonesia, Thailand expressed interest in participating in the project. A new work plan was created for Thailand and research was begun on the Bang Pakong and Mae Klong River Basins in Thailand. A goal of the project is to develop methods to link assessments of physical characteristics, water accounting, irrigation performance assessment, and socio-economic analysis in a manner that will improve the management of scarce water supplies within river basins. The overall purpose is to develop a framework for water management that is comprehensive and integrated, participatory and responsive, and dynamic and strategic. Within this framework, policies and institutions can be improved and strengthened which will in turn improve the management of water resources. The study can be characterized by three components: water accounting, socio-economic analysis and irrigation performance assessment, and institutional analysis.

In October 2001, a field trip was taken by members of the IWMI and Kasetsart University research teams. Visits were taken to the Bang Pakong Diversion Dam, the Pra Ong Chaiyanuchit Irrigation Project, the Talat Irrigation System, and the Bang Plung Operations and Maintenance Irrigation Project. Additional visits were taken to observe the physical conditions of the irrigations systems and upstream and downstream river conditions. Information gained from these visits is included in this report.

Some of this report has been translated to Thai language (see Annex 1), such as Chapter 1: Introduction and General Basin Description, Chapter 2: Water Accounting Analysis, and Socio-economic Analysis.

General Description to Thailand and the Bang Pakong River Basin

Thailand is located in a tropical monsoon zone subject to the southwest monsoon during the period from May to October and the tropical cyclonic storm from South China Sea during the end of the rainy season between September and October. The total population is approximately 62 million. The majority of population is in the agriculture sector but the majority of country income is generated from the industrial sector. The country consists of 25 major river basins. The annual rainfall varies between 900 and 1,500 mm per year with an average annual rainfall of between about 1,000 to 1,300 mm per year. Due to Thailand's location in the tropical latitudes, temperature is uniform throughout the year with small seasonal variation around the mean of 28 °C. The average temperature in the hottest month (April) is 32 °C while the average temperature at the coldest month (December) is 25 °C.

The Bang Pakong River Basin is located in the east of Thailand. The basin has a drainage area of 18,500 km^2 and a reservoir storage capacity of 131 mcm. The total irrigated area is reported to be 2.1 million rai (3,328 km^2).[1] The average annual mean runoff is 3,712 mcm. The major infrastructural characteristic of the basin is the Bang Pakong Diversion Dam. The dam is designed to regulate the flow of water to reduce salinity intrusion during the dry season. Irrigation systems in the basin tend to be small.

The hydrologic basin is comprised of two administrative river basins: the Bang Pakong River Basin or the Lower Bang Pakong Rriver Basin and the Prachinburi River Basin or the Upper Bang Pakong River Basin. For the purposes of this study, the basin was sub-divided into seven study areas. Choice of the study area boundaries was determined based on the location of gauging stations, which facilitated the collection of data for the Water Accounting analysis (see map in Annex 2). The flow of the river begins in Khlong Phra Sathung which flows into Khlong Phra Prong. The Mae Nam Hanuman basin, together with water from Khlong Phra Prong flows in to the Main Prachinburi River. This finally flows into the Main Bang Pakong and Talat[2] area before flowing into the sea. Two other sub-basins are the Nakhon Nayok and Khlong Luang which each flows directly into the Main Bang Pakong and Talat Basin. Data for this study is presented in a manner that attempts to arrange the study areas in an upstream to downstream direction. However, reference to the maps should be made to get the most accurate idea of the River's layout. Movements downstream correspond to increased proximity to more densely populated urban centers, particularly Bangkok. It is hope that by presenting data in an upstream-to-downstream manner, a better understanding of the spatial aspects of the socio-economic conditions can be ascertained. Codes were devised to represent the names of the different sub-basins in an abbreviated fashion. These codes are presented in Table 1

• Table 1 Code Abbreviations for Study Areas in the Bang Pakong River Basin

Study Area	**Code**
Khlong Phra Sathung	KPS
Khlong Phra Prong	KPP
Mae Nam Hanuman	MNH
Main Prachinburi	MP
Nakhon Nayok	NN
Khlong Luang	KL
Main Bang Pakong + Talat	MBP+T

[1] Department of Irrigation Engineering (2002). Water Resources of 25 River Basins of Thailand, Kasetsart University. 2002. www.eng.ku.ac.th/~irre/E25BASIN.HTM

[2] In the map in Annex , the Main Bang Pakong and Talat area is made up of areas 5, 7, and 8.

Chapter

2

Water Accounting Analysis

At present, the water resource management is significant for everybody because human needs the water for drinking and using in various activities while there is very limit water in dry season, but has too much in wet season and flooding. Water accounting analysis is one of many methodologies in water resources management. This chapter is presents five topics of water accounting that are definition and assumption of water accounting, characteristic of the Bang Pakong River Basin, selection of representation year, water accounting analysis, and water accounting indicator.

Definition and Assumption

Water accounting terms have been defined and applied to several river basins (Molden, 1997). The amount of water for each term can be calculated using different methods depending upon available data and information. The methods and assumptions used in this study for the Bang Pakong River Basin are presented as follows.

1) Domain represents a basin that includes agricultural, industrial, domestic, and environmental uses of water. The water balance domains are selected so the area corresponds to a management unit and the inflows and outflows could be estimated with minimal difficulties. The interested domains presented here are seven sub-basins in the Bang Pakong River Basin that are Khlong Phra Sathung, Khlong Phra Prong, Mae Nam Hanuman, Main Prachinburi, Nakhon Nayok, Talat, Khlong Luang and Main Bang Pakong Sub-Basin.

2) Gross inflow (GI) is the total amount of water entering into the water balance domain from precipitation, surface and subsurface sources.

- Precipitation (PP) is the multiplication of arithmetic mean monthly depths of rain over the watershed area. The arithmetic mean monthly rainfall is calculated using average rainfall from several rain gage stations over their coverage area.

- Surface inflow (SI) is surface flow across the domain boundary on the basin or sub-basin.

- Sub-surface inflow (SSI) is groundwater flow across the underground domain boundary into the domain groundwater. The groundwater inflows and outflow are assumed to be negligible compared to other inflow components.

3) Net inflow (NI) is the gross inflow plus any changes in storage. Amount of gross inflow could be decreases if some water goes into surface or subsurface storage or both. Otherwise, it could be increased due to some amount of water from storage.

4) Storage (S) is separated into two layers as surface and sub-surface storages.

- Surface storage is volume space on ground surface such as reservoirs, natural channel, ponds, rivers, and canals. The surface storage from several reservoirs in the domain is assumed to be 90% of the total retention storage volumes. While the total surface storage volume in the rivers, canals, and natural ponds are assumed to be the different between the volume of minimum monthly outflow and the volume of outflow at the beginning of wet season.

- Sub-surface storage is ground water storage. It could be calculated as changing in level of water table multiplied by watershed area and its specific yield. The specific yields are assumed according to characteristics of soil and rock.

5) Water depletion (WD) is a use or removal of water from a water basin that renders it unavailable for further use. Water depletion is a key concept for water accounting, as interest is focused mostly on the productivity and the derived benefits per unit of water depleted. It is extremely important to distinguish water depletion from water diverted to a service or use. This is based on the reason that not all water diverted to a use is depleted. Water is depleted by four generic processes:

- Evaporation (E): water is vaporized from surfaces or transpired by plants. The estimation of crop evapotranspiration is the multiplication of crop coefficient and potential evapotranspiration calculated by the Penman-Monthieth method suggested by the FAO (Doorenbos and Puitt, 1977).

- Flows to sinks (FS): water flows into a sea, saline groundwater, or other location where it is not readily or economically recovered for reuse.

- Pollution: water quality gets degraded to an extent that it is unfit for certain uses.

- Incorporation into a product: through an industrial or agricultural process, such as bottling water or incorporation of water into plant tissues.

6) Process consumption (P) is that amount of water diverted and depleted to produce a human-intended product. The process depletion includes crop evapotranspiration plus consumption from domestic and industrial uses.

7) Non-process depletion (NP) occurs when water is depleted, but not by the process for which it was intended. Non-process depletion can be either beneficial, or non-beneficial.

- Beneficial non-process depletion (B) is such as home garden and forest evapotranspiration.

- Non-beneficial non-process depletion (NB) is as flow to sinks and low quality of water.

8) Committed water (C) is that part of outflow from the water balance domain that is committed to other uses, such as downstream environmental requirements or downstream water rights. Committed water outflow here in this study is the amount of downstream flow to maintain sustainable ecology or environmental requirement. As unavailable of water right among sub-basins in the Bang Pakong river basin, no committed outflow is presently provided for the downstream sub-basins.

9) Uncommitted outflow (UC) is water that neither depleted, nor committed and is, therefore, available for a use within the domain, but flows out of the basin due to lack

of storage or sufficient operational measures. Uncommitted outflow can be classified as utilizable or non-utilizable.

- Utilizable outflow (UO) is utilizable if by improved management of existing facilities it could be consumptively used.
- Non-utilizable outflow (NUO) exists when the facilities are not sufficient to capture the otherwise utilizable outflow.

10) Available water (AW) is the net inflow minus both the amount of water set aside for committed uses and the non-utilizable uncommitted outflow. It represents the amount of water available for use at the basin, service, or use levels. Available water includes process and non-process depletion plus utilizable outflows.

11) A closed basin is the basin where all available water is depleted.

12) An open basin is the basin where there is still some uncommitted utilizable outflow.

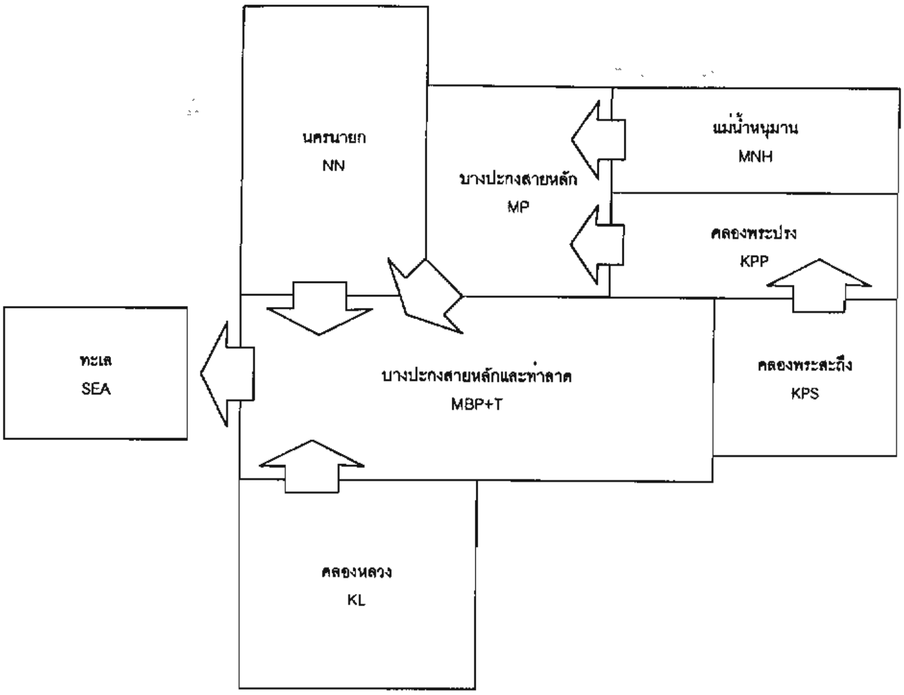
13) Fully committed basins there are no uncommitted outflows. All inflowing water is committed to various uses.

Characteristic of the Bang Pakong River Basin

The Bang Pakong River Basin has a drainage area of 18,500 sq. km., comprised of Prachinburi and Bang Pakong main rivers. The Prachinburi River Basin or the Upper Bang Pakong River Basin, which has a drainage area of 9,821 sq. km., is comprised of four sub-basins: Khlong Phra Sathung, Khlong Phra Prong, Mae Nam Hanuman, and Main Prachinburi Sub-Basin. The Bang Pakong River Basin or the Lower Bang Pakong River Basin has a drainage area of 8,679 sq. km., and consists of four sub-basins: Nakhon Nayok, Talat, Khlong Luang, and Main Bang Pakong River Basins, as shown in Annex 2.

The Prachinburi River Basin is the upstream basin, and then Khlong Phra Sathung and Mae Nam Hanuman Sub-Basin are not inflow another sub-basin. The Nakhon Nayok and Khlong Luang Sub-Basins have no inflows as they are located at the upper part of the Bang Pakong River Basin. The outflow from Khlong Phra Sathung Sub-Basin flows into the Phra Prong Sub-Basin. The outflow from Phra Prong Sub-basin and Hanuman Sub-Basin flows into the Main Prachinburi Sub-Basin. The outflows from Main Prachinburi Sub-Basin, Nakhon Nayok Sub-Basin, and Khlong Luang Sub-Basin flow to the Main Bang Pakong and Talat Sub-Basin as shown on Figure 1.

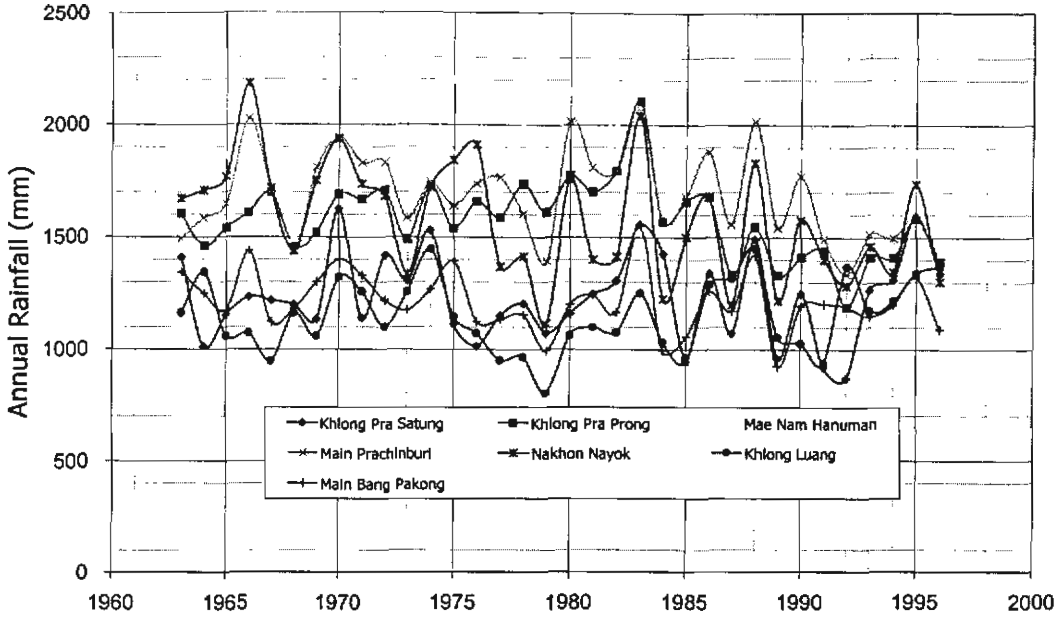
Annex 2 is presents the Map of the Bang Pakong River Basin and location of rainfall gauging station and runoff station which used to analyses water accounting.



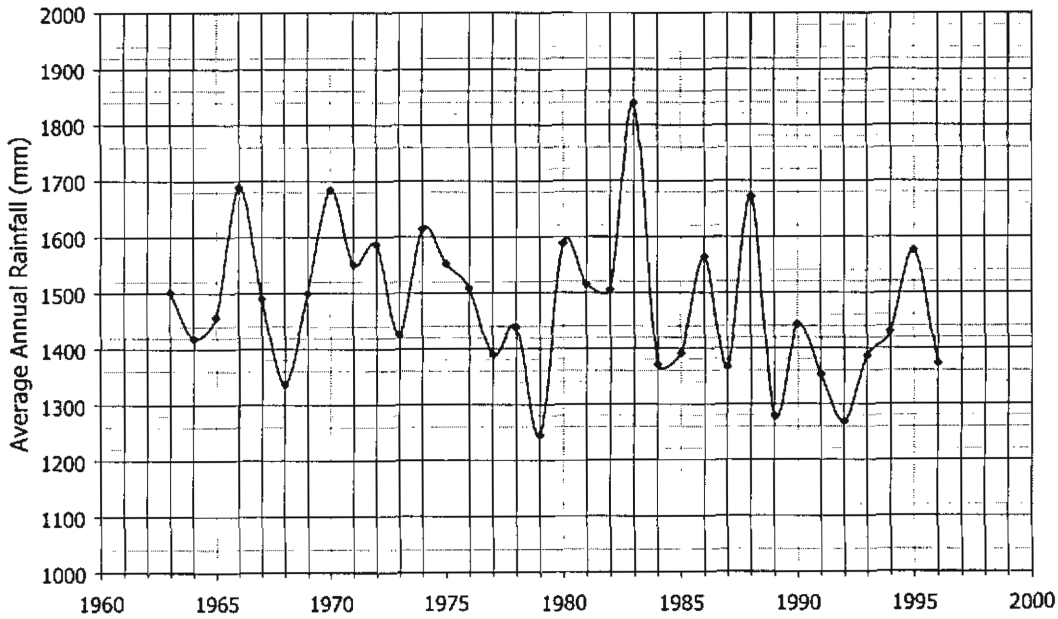
• Figure 1 Schematic Diagram of the Bang Pakong River Basin

Selection of Representative Year

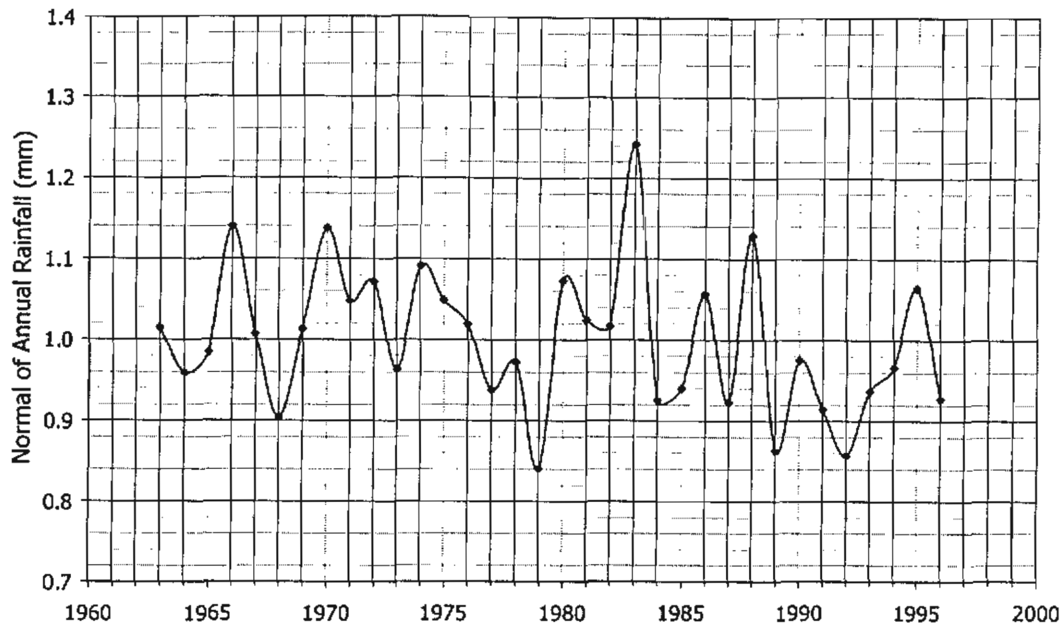
In this study, representative years were selected for a normal year, wet year, and dry year in the study area. The methodology of representative year selection is based on rainfall data observed at the rainfall gauging station for each sub-basin from 1963 to 1996). The relationship between annual rainfall and years are analyzed to find the trend for each sub-basin as show on Figure 2. From this curve, the trends of each sub-basin are similar curve. In the same year, all sub-basins do not simultaneously experience maximum rainfall or minimum rainfall because of the different locations, for example, in 1996 Mae Nam Hanuman had the maximum rainfall, while Khlong Luang was nearly at minimum rainfall. The next step was to collect the average annual rainfalls of the seven sub-basins to build the curve of relationship for the 34 values as show on Figure 3. The method to normalize the trend analysis was to select the representative years as show on Figure 4. As usual, the normalized value is nearly "1" because the rainfall in this year has nearly average rainfall for the 34 values. If the normalized value is more than 1, it is represented wet year because it has more rainfall than average rainfall for the 34 values. While normalized value is less than 1, it is represented dry year it has less rainfall than average rainfall for the 34 values. The analysis of Figure 4 can be present the standard normalized value in several years. In the year 1976, 1982 and 1994, the normalized value has nearly 1, which the year of 1994 is selected to represent the normal year while 1995 and 1996 are selected to represent the wet year and dry year, respectively, because these year is the new record data.



• Figure 2 Annual Rainfall of Sub basin in the Bang Pakong River Basin



• Figure 3 Average Annual Rainfall of the Bang Pakong River Basin



• Figure 4 Normalized Trend Analysis of Average Annual Rainfall in the Bang Pakong River Basin

Water Accounting Analysis

Water balance studies were used to generate the water accounting components for each domain or sub-basin site. The first four sub-basins are in the Prachinburi River Basin and are the upstream region of the Bang Pakong River Basin. The remaining three sub-basins were in the lower part of the Bang Pakong River Basin.

Water accounting relies on water balance for a domain bounded in space and time. The calculations for each sub-basin were analyzed for wet season and dry season (the wet season is from April to October and the dry season is from November to March). The processes of water accounting analysis are as follow:

Gross inflow

Gross inflow (GI) is the total amount of water entering into the water balance domain from precipitation, surface and subsurface sources.

$$GI = PP + SI + SSI \qquad (1)$$

Where PP is the precipitation, SI is the surface inflow and SSI is the sub-surface inflow.

In this study, precipitation was collected from rainfall data for the years 1994, 1995, and 1996 representative of a normal year, wet year, and dry year, respectively.

The Bang Pakong River Basin has two sections, the upper river basin and the lower basin. The upper river basin includes Khlong Phra Sathung, Mae Nam Hanuman, Nakhon Nayok and Khlong Luang Sub-Basin. The lower river basin includes Khlong Phra Prong, Main Prachinburi, Main Bang Pakong and Talat Sub-Basin. Since the upper river basin not has the surface runoff then the surface runoff in the equation (1) is the zero while the lower river basin has the surface runoff from the upper river basin as shown on Figure 2.

Sub-surface inflow in this study is neglected because this data is difficult to measure and survey and theyare small in comparison with rainfall and surface inflow.

Net Inflow

Net Inflow (NI) is the gross inflow plus any changes in storage as shown:

$$NI = GI + \Delta S \tag{2}$$

Where NI is the net inflow, GI is the gross inflow and ΔS is changes in storage within the domain consisting of changes in surface water and subsurface water (groundwater). The reservoir storage of domain is assumed as 90% of total reservoir storage. Water storage of river, pond and reservoir are calculating from the difference between of the minimum monthly outflow and outflow in the early wet season.

The storage of groundwater is estimate from the rainfall in the area. The groundwater storage in eastern of Thailand is about 4-6% of rainfall in sub-basin. This assumption was recommended by Dr. Wajee Ramronanrong (2000) whose do many researches on groundwater storage in Thailand.

Depleted Water

Depleted water is calculated by the following equation:

$$D = P + B + NB \tag{3}$$

Where D is the deplete water, P is the process consumption, B is the beneficial non-process depletion and NB is the non - beneficial non-process depletion.

Climatological data for calculated potential evapotranspiration is gathered at the three synoptic stations of the Meteorology Departments at Prachinburi, Aranyaprathet, and Chonburi, which were selected to describe the climate of the study area. The analysis of climatological data was based on data collected from this three synoptic stations to describe the general characteristic of the basin.

The Penman-Monthieth equation is used to calculate the potential evapotranspiration. The potential evapotranspiration of Khlong Pra Sathung Sub-Basin is analyzed based on data from Prachinburi and Aranyaprathet rainfall stations, while Khlong Pra Pong, Mae Nam Hanuman, Main Prachinburi, and Nakhon Nayok Sub-Basins are analyzed from Prahinburi rainfall stations. Furthermore, the potential evapotranspiration of the Main Bang Pakong and Talat Sub-basins are analyzed using data from Prachinburi and Chonburi rainfall stations.

Evapotranspiration (ET) is crop water used under ideal conditions. The method of calculation uses the product of a crop coefficient, K_c, and potential evapotranspiration from a reference crop, Etp, to determine values of ET. The evapotranspiration is analyzed for each land use because of the differences in K_c such as bare land has a Kc between 0.2 and 0.3, while forestland has K_c between 0.7 and 0.9. In this study, monthly K_c is used for the analysis. The volume of evapotranspiration is the product of crop coefficient, potential evapotranspiration, and area for each land use.

Municipal and industrial (M&I) uses were utilized to represent non-agricultural water uses, such as towns and factories. M&I water requirements are specified for each sub-basin. Data for M&I was collected from "A Study on Master Plan for Water Resources Development and Management in Eastern Region" (prepared by the Department of Water Resources Engineering, Kasetsart University) with data available for the year 1996 and

2000. A linear equation from available data is use to established M&I water requirements for the study year.

Outflow

Outflow (O) from a domain was either classified as committed or non-committed. Outflow is calculated using the following equation:

$$O = NI - D \qquad (4)$$

Where the NI is the net inflow and D is the depletion of water.

In this study, committed and uncommitted outflow is approximated to 3% and 97% of total sub-basin outflow, respectively. Utilizable and non-utilizable outflow is set to 10% and 87% of total sub-basin outflow. The percentage of committed outflow is estimated from the percentage of minimum flow in dry season to maintain ecology and environmental which release to downstream sub-basin, because there are no water rights or water laws in Thailand, so there are no criteria for release water to downstream area or environment.

Available Water

Available Water (AW) indicates how much water depleting within the water accounting domain without effecting present downstream uses. Available water is the net inflow minus the sum of any downstream commitments to meet water rights or environmental needs plus any non-utilizable flows. Available water is calculated by the following equation:

$$AW = NI - C - NUO \qquad (5)$$

Where NI is the net inflow, C is the committed water and NUO is the non-utilizable out flow.

Verification

The components required for the analysis of water accounting are rainfall, groundwater, reservoirs, water storage, and water used. To verify the water accounting, two methods were employed to check the accuracy. The first method was employed after conducting the water accounting; where the outflow of the upper sub-basin equals the inflow of lower sub-basin. The Water Resource Engineering Department at Kasetsart University analyzed the outflow of each sub-basin for the whole Bang Pakong River Basin. From comparisons of outflow between previously reported research and water accounting, it was found that the most error occurred at the Main Prachinburi in every year.

For the second method, the crop coefficient is used to check the correctness of this study. The crop coefficient is the difference between net inflow and outflow divided by the product of area and potential evapotranspiration. At Main Prachinburi in every year, the K_c is little higher than 1.3, which is the maximum value.

Results

Tables 2 to 7 is presents the result of water accounting analysis, which Tables 2 and 5 are display the result in the 1994 (normal year), Tables 3 and 6 are display the result in the 1995 (wet year) and Tables 4 and 7 are display the result in the 1996 (dry year). The calculation of each item in Tables 2 to 7 is shown in Annex 4. Results from Tables 2 to 7 can illustrate as finger diagram as shown in Figures 5 and 6. Figure 5 is the water accounting diagram of Khlong Pra Sathung Sub-Basin in the 1994 (normal year) and

Figure 6 is the water accounting diagram of Main Bang Pakong and Talat Sub-Basin in the 1994 (normal year). These two figures are showing the water accounting analysis in the wet season, dry season and whole year. The whole water accounting diagrams of the Bang Pakong River Basin are shown in Annex 4.

Water Accounting Indicators

Water accounting indicators are fractions used to indicate use efficiency and to describe the current state of the system. These values can be used to predict future trends in water resources. The following indicators are available for use:

1) Depleted Fraction of Gross Inflow (DF_{GI}) indicates how much of the gross inflow was depleted by various uses.

$$DF_{GI} = D / GI$$

Where D is the total depletion, calculate from P + NP, P is the process consumption, NP is the non-process depleted and GI is the gross inflow.

14) Depleted Fraction of Available Water (DF_{AW}) indicates how much water that was available for use has been depleted.

$$DF_{AW} = D / AW$$

Where D is the deplete water and AW is the available water.

15) Process Fraction of Available Water (PF_{AW}) indicates how much of the available water was deplete by process uses.

$$PF_{AW} = P / AW$$

Where P is the process consumption and AW is the available water.

16) Process Fraction of Available Water for Agriculture ($PW_{AW\text{-}ag}$) same as the PF_{AW} but isolates agricultural uses from other uses. To do this we deduct non-agricultural uses that are beneficial but depletive from the available water such as domestic and industrial uses and forest evaporation.

$$PW_{AW\text{-}ag} = ET / AW_{ag}$$

Where ET is the evaporation and AW_{ag} is the available water for agriculture.

The available water for agriculture (AW_{ag}) can be calculated as follow.

$$AW_{ag} = NI - C - NUO - D_{bnag}$$

Where NI is the net inflow, C is the committed water, NUO is the non-utilizable outflow and D_{bnag} is the beneficial depleted water for non-agricultural.

The beneficial depleted water for non-agricultural can be calculate as follow.

$$D_{bnag} = P_{nag} + B_{nag}$$

Where P_{nag} is the process consumption for non-agricultural and B_{nag} is the beneficial non-process depletion for non-agricultural.

17) Process Fraction of Depleted Water (PF_{TD}) indicates how much of the depleted water was deplete by process uses.

$$PF_{TD} = P / D$$

Where P is the process consumption and D is the depleted water.

18) Beneficial Utilization of Available Water or Basin Efficiency (BU or BE) indicates how much of the available water was depleted beneficially by both process and non-process uses.

$$BU \text{ or } BE = D_b / AW$$

Where D_b is the beneficial depleted water and AW is the available water.

The water indicators of the Bang Pakong river basin are shown in Tables 2 to 7 which contain data of the water accounting analysis and calculated indicators. Result of indicators in Tables 2 to 7 can illustrate as diagram as shown in Figure 7 which is the water indicator diagram of depleted fraction of gross inflow (DF_{GI}) of the Bang Pakong river basin of wet season in 1994 (normal year). The whole water indicator diagrams of the Bang Pakong river basin are shown in Annex 5.

From Tables 2 to 7, the value of DF_{GI} are less than unit in wet season (0.40 - 0.70) and higher than unit in dry season (2.00 - 4.00). Its show that gross inflow in wet season is larger than depleted water, so some exceeding water may collected in storage such as reservoirs, natural channel, ponds, rivers, and canals. But In dry season, gross inflow in domain is less than depleted water so it is necessary to use water from storage which collected in wet season. If considering DF_{GI} respect to the location of domain, most upstream domains have higher DF_{GI} value than downstream domains because surface outflow and sub-surface outflow from upstream domains are flow to downstream domains and give large volume of gross inflow in downstream domains when comparison with depleted water.

Most of DF_{AW} value in Tables 2 to 7 is higher than 90%, it shows that most available water in domains was depleted. Development in this domain should do in management section such as modifying crop schedule, crop pattern, or other product increasing method because the potential for infrastructure development is only 10 %, its may be not economically when compare with management development.

The PF_{AW} has average volume of 70 %, it means 70% of available water was used for process depletion. Different percentage of PF_{AW} and DF_{AW} is non-process depletion water (about 10-20%), so if we want to increasing water for process depletion, should do by decreasing non-process depletion such as decrease flow to sink or improve water quality. If consider only agriculture water use, an analysis demonstrates that $PF_{AW\text{-}ag}$ has higher value as PF_{AW}, so to increase water for agriculture use should decreasing non intended use such as non-agriculture process depletion or un-committed outflow by improve the basin management.

The process fraction of depleted water or PF_{TD} in the study has average value of 80%. This demonstrate that 80% of depleted water was use by human intended and the rest 20% was use by the process for which it was not intended and can be either beneficial, or non-beneficial.

From above indicator, we can summarize results as basin efficiency (BE). Basin efficiency of the Bang Pakong river basin has an average value of 90. This demonstrates that water use activities in this basin were efficiency or 90% of available water is beneficial water use.

When compare BE with PF_{AW}, BE has higher value than PF_{AW} about 20%. This shows that 20% of available water which are non-process depletion is beneficial such as home garden and forest evapotranspiration.

• Table 2 Water Accounting Data and Calculated Indicators for the Upper Bang Pakong River Basin (1994 = normal)

Items	Khlong Phra Sathung			Khlong Phra Prong			Mae Nam Hanuman			Main Prachinburi		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	3,021.8	398.0	3,419.8	4,148.8	366.0	4,514.8	4,022.3	265.2	4,287.6	6,810.0	346.8	7,156.8
Surface Inflow	0.0	0.0	0.0	828.6	55.8	884.4	0.0	0.0	0.0	3,261.0	114.5	3,375.5
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	3,021.8	398.0	3,419.8	3,320.2	310.2	3,630.4	4,022.3	265.2	4,287.6	3,548.9	232.3	3,781.2
Net Inflow	2,625.2	794.7	3,419.8	3,630.3	884.5	4,514.8	3,328.8	958.8	4,287.6	6,240.4	916.4	7,156.8
Gross Inflow	3,021.8	398.0	3,419.8	4,148.8	366.0	4,514.8	4,022.3	265.2	4,287.6	6,810.0	346.8	7,156.8
ΔStorage	396.6	-396.6	0.0	518.5	-518.5	0.0	693.5	-693.5	0.0	569.6	-569.6	0.0
Net Inflow	2,625.2	794.7	3,419.8	3,630.3	884.5	4,514.8	3,328.8	958.8	4,287.6	6,240.4	916.4	7,156.8
Depleted Water	1,796.6	738.9	2,535.5	1,864.2	802.2	2,666.5	1,833.8	926.5	2,760.4	2,155.4	893.9	3,049.3
Process Water	1,488.7	618.8	2,107.5	1,508.3	654.1	2,162.4	629.7	287.2	916.9	1,879.4	706.0	2,585.4
Water uses intended by humans	0.9	0.9	1.8	0.9	0.9	1.8	0.4	0.4	0.7	1.5	1.5	3.0
Evapotranspiration by crops (ET)	1,359.7	612.8	1,972.5	1,366.8	649.0	2,015.8	468.0	281.1	749.1	1,698.6	693.4	2,392.0
Evaporation from municipal and industrial uses (M&I)	1.1	1.1	2.2	1.1	1.1	2.2	0.5	0.5	0.9	1.9	1.9	3.7
Beneficial Non-process Water	307.9	120.1	428.0	355.9	148.1	504.0	1,203.7	638.8	1,842.5	275.3	187.0	462.3
Low or Non-beneficial Non-process Water	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	1.0	0.7	0.9	1.6
% Compare with Rainfall	4.2	1.0	3.8	4.2	1.0	3.9	4.0	2.0	3.9	5.0	4.0	4.9
Flows to sinks	126.9	4.0	130.9	139.4	3.1	142.6	160.9	5.3	166.2	177.4	9.3	186.7
Available Water	1,879.4	744.5	2,623.9	2,040.8	810.4	2,851.3	1,983.3	929.8	2,913.1	2,563.9	896.2	3,460.1
Outflow (VP)	773.9	48.3	822.2	1,724.2	74.1	1,798.2	1,434.9	31.7	1,466.6	2,460.0	6.3	2,466.3
% Compare with VP	107.1	115.5	107.6	102.4	111.1	102.8	104.2	101.5	104.1	166.1	357.5	166.5
Outflow	828.6	55.8	884.4	1,766.1	82.3	1,848.3	1,495.0	32.2	1,527.2	4,085.0	22.5	4,107.5
Uncommitted Outflow	803.7	54.1	857.9	1,713.1	79.8	1,792.9	1,450.1	31.3	1,481.4	3,962.4	21.8	3,984.2
Utilizable Outflow	82.9	5.6	88.4	176.6	8.2	184.8	149.5	3.2	152.7	408.5	2.2	410.7
Non-utilizable Outflow	720.9	48.5	769.4	1,536.5	71.6	1,608.1	1,300.6	28.0	1,328.7	3,553.9	19.6	3,573.5
Committed Outflow	24.9	1.7	26.5	53.0	2.5	55.5	44.8	1.0	45.8	122.5	0.7	123.2
Depleted Fraction of Gross Inflow (DF_{GI})	0.59	1.86	0.74	0.45	2.19	0.59	0.46	3.49	0.64	0.32	2.58	0.43
Depleted Fraction of Available Water (DF_{AW})	0.96	0.99	0.97	0.91	0.99	0.94	0.92	1.00	0.95	0.84	1.00	0.88
Process Fraction of Available Water (PF_{AW})	0.79	0.83	0.80	0.74	0.81	0.76	0.32	0.31	0.31	0.73	0.79	0.75
Process Fraction of Available Water for Agriculture (PF_{AW-ag})	0.80	0.91	0.83	0.75	0.90	0.79	0.37	0.52	0.41	0.71	0.89	0.75
Process Fraction of Depleted Water (PF_{TD})	0.83	0.84	0.83	0.81	0.82	0.81	0.34	0.31	0.33	0.87	0.79	0.85
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.96	0.99	0.97	0.91	0.99	0.94	0.92	1.00	0.95	0.84	1.00	0.88

• Table 3 Water Accounting Data and Calculated Indicators for the Upper Bang Pakong River Basin (1995 = wet)

Items	Khlong Phra Sathung			Khlong Phra Prong			Mae Nam Hanuman			Main Prachinburi		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	3,708.7	441.9	4,150.7	5,048.1	468.0	5,516.1	3,581.6	381.2	3,962.8	7,660.5	353.8	8,014.3
Surface Inflow	0.0	0.0	0.0	1,393.6	47.0	1,440.6	0.0	0.0	0.0	3,905.0	113.9	4,018.9
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	3,708.7	441.9	4,150.7	3,654.5	421.0	4,075.5	3,581.6	381.2	3,962.8	3,755.5	239.9	3,995.4
Net Inflow	3,275.6	875.1	4,150.7	4,564.0	952.1	5,516.1	2,974.9	987.8	3,962.8	7,130.0	884.3	8,014.3
Gross Inflow	3,708.7	441.9	4,150.7	5,048.1	468.0	5,516.1	3,581.6	381.2	3,962.8	7,660.5	353.8	8,014.3
ΔStorage	433.2	-433.2	0.0	484.1	-484.1	0.0	606.7	-606.7	0.0	530.5	-530.5	0.0
Net Inflow	3,275.6	875.1	4,150.7	4,564.0	952.1	5,516.1	2,974.9	987.8	3,962.8	7,130.0	884.3	8,014.3
Depleted Water	1,882.0	828.1	2,710.1	1,961.1	881.8	2,842.9	1,672.9	944.3	2,617.1	2,395.1	880.1	3,275.2
Process Water	1,635.7	553.7	2,189.4	1,676.3	649.1	2,325.4	751.8	318.3	1,070.2	2,184.6	707.8	2,892.4
Water uses intended by humans	1.0	0.9	1.9	1.1	1.0	2.1	0.5	0.5	0.9	1.6	1.6	3.2
Evapotranspiration by crops (ET)	1,633.6	551.5	2,185.1	1,308.5	642.5	1,950.9	715.0	309.7	1,024.7	1,242.0	694.6	1,936.7
Evaporation from municipal and industrial uses (M&I)	1.2	1.2	2.4	1.3	1.3	2.6	0.6	0.6	1.2	2.0	2.0	4.1
Beneficial Non-process Water	246.3	274.4	520.7	284.8	232.7	517.5	920.6	625.4	1,546.0	209.8	171.4	381.2
Low or Non-beneficial Non-process Water	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	1.0	0.7	0.9	1.6
% Compare with Rainfall	0.0	0.0	0.0	10.0	1.0	9.1	1.0	2.0	1.1	25.0	4.0	23.7
Flows to sinks	0.0	0.0	0.0	365.5	4.2	369.7	35.8	7.6	43.4	938.9	9.6	948.5
Available Water	2,021.4	832.8	2,854.2	2,221.4	888.8	3,110.2	1,803.1	948.6	2,751.7	2,868.6	880.6	3,749.1
Outflow (VP)	773.9	48.3	822.2	1,724.2	74.1	1,798.2	1,434.9	31.7	1,466.6	2,460.0	6.3	2,466.3
% Compare with VP	180.1	97.4	175.2	151.0	95.0	148.7	90.7	137.3	91.7	192.5	65.6	192.2
Outflow	1,393.6	47.0	1,440.6	2,602.9	70.3	2,673.2	1,302.1	43.6	1,345.6	4,734.9	4.1	4,739.1
Uncommitted Outflow	1,351.8	45.6	1,397.4	2,524.8	68.2	2,593.1	1,263.0	42.3	1,305.3	4,592.9	4.0	4,596.9
Utilizable Outflow	139.4	4.7	144.1	260.3	7.0	267.3	130.2	4.4	134.6	473.5	0.4	473.9
Non-utilizable Outflow	1,212.4	40.9	1,253.3	2,264.5	61.2	2,325.7	1,132.8	37.9	1,170.7	4,119.4	3.6	4,123.0
Committed Outflow	41.8	1.4	43.2	78.1	2.1	80.2	39.1	1.3	40.4	142.0	0.1	142.2
Depleted Fraction of Gross Inflow (DF_{GI})	0.51	1.87	0.65	0.39	1.88	0.52	0.47	2.48	0.66	0.31	2.49	0.41
Depleted Fraction of Available Water (DF_{AW})	0.93	0.99	0.95	0.88	0.99	0.91	0.93	1.00	0.95	0.83	1.00	0.87
Process Fraction of Available Water (PF_{AW})	0.81	0.66	0.77	0.75	0.73	0.75	0.42	0.34	0.39	0.76	0.80	0.77
Process Fraction of Available Water for Agriculture ($PF_{AW\text{-}ag}$)	0.87	0.83	0.86	0.64	0.86	0.70	0.57	0.54	0.56	0.45	0.90	0.55
Process Fraction of Depleted Water (PF_{TD})	0.87	0.67	0.81	0.85	0.74	0.82	0.45	0.34	0.41	0.91	0.80	0.88
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.93	0.99	0.95	0.88	0.99	0.91	0.93	0.99	0.95	0.83	1.00	0.87

• Table 4 Water Accounting Data and Calculated Indicators for the Upper Bang Pakong River Basin (1996 = dry)

Items	Khlong Phra Sathung			Khlong Phra Prong			Mae Nam Hanuman			Main Prachinburi		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	2871.2	617.0	3488.2	3642.6	743.1	4385.7	3149.3	521.5	3670.9	5723.6	570.8	6294.4
Surface Inflow	0.0	0.0	0.0	724.9	73.4	798.4	0.0	0.0	0.0	2587.8	223.3	2811.1
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	2871.2	617.0	3488.2	2917.6	669.7	3587.3	3149.3	521.5	3670.9	3135.8	347.5	3483.3
Net Inflow	2502.6	985.6	3488.2	3180.5	1205.3	4385.7	2555.2	1115.7	3670.9	5217.2	1077.2	6294.4
Gross Inflow	2871.2	617.0	3488.2	3642.6	743.1	4385.7	3149.3	521.5	3670.9	5723.6	570.8	6294.4
ΔStorage	368.6	-368.6	0.0	462.1	-462.1	0.0	594.1	-594.1	0.0	506.4	-506.4	0.0
Net Inflow	2502.6	985.6	3488.2	3180.5	1205.3	4385.7	2555.2	1115.7	3670.9	5217.2	1077.2	6294.4
Depleted Water	1777.6	912.2	2689.8	1770.9	1044.4	2815.3	1377.0	1053.3	2430.3	2047.2	1033.8	3081.1
Process Water	1531.3	672.1	2203.5	1521.7	748.2	2269.9	675.1	375.3	1050.4	1784.3	830.4	2614.7
Water uses intended by humans	1.0	1.0	2.1	1.1	1.0	2.1	0.5	0.5	1.0	1.7	1.7	3.4
Evapotranspiration by crops (ET)	1328.0	663.6	1991.7	1227.6	739.1	1966.7	642.6	363.8	1006.3	1623.7	812.7	2436.3
Evaporation from municipal and industrial uses (M&I)	1.3	1.3	2.6	1.3	1.3	2.6	0.6	0.6	1.2	2.1	2.1	4.3
Beneficial Non-process Water	246.3	240.1	486.4	249.2	296.2	545.4	701.4	677.5	1378.9	262.2	202.6	464.8
Low or Non-beneficial Non-process Water	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	1.0	0.7	0.9	1.6
% Compare with Rainfall	7.0	1.0	5.9	10.0	1.0	8.3	1.0	2.0	1.1	5.0	4.0	4.9
Flows to sinks	201.0	6.2	207.2	291.8	6.7	298.5	31.5	10.4	41.9	156.8	13.9	170.7
Available Water	1850.1	919.6	2769.7	1911.8	1060.5	2972.3	1494.8	1059.5	2554.3	2364.2	1038.2	3402.4
Outflow (VP)	773.9	48.3	822.2	1724.2	74.1	1798.2	1434.9	31.7	1466.6	2460.0	6.3	2466.3
% Compare with VP	93.7	152.1	97.1	81.8	217.3	87.3	82.1	196.5	84.6	128.9	689.8	130.3
Outflow	724.9	73.4	798.4	1409.6	160.9	1570.5	1178.2	62.4	1240.6	3169.9	43.4	3213.3
Uncommitted Outflow	703.2	71.2	774.4	1367.3	156.1	1523.3	1142.9	60.5	1203.4	3074.8	42.1	3116.9
Utilizable Outflow	72.5	7.3	79.8	141.0	16.1	157.0	117.8	6.2	124.1	317.0	4.3	321.3
Non-utilizable Outflow	630.7	63.9	694.6	1226.3	140.0	1366.3	1025.0	54.3	1079.3	2757.8	37.7	2795.6
Committed Outflow	21.7	2.2	24.0	42.3	4.8	47.1	35.3	1.9	37.2	95.1	1.3	96.4
Depleted Fraction of Gross Inflow (DF_{GI})	0.62	1.48	0.77	0.49	1.41	0.64	0.44	2.02	0.66	0.36	1.81	0.49
Depleted Fraction of Available Water (DF_{AW})	0.96	0.99	0.97	0.93	0.98	0.95	0.92	0.99	0.95	0.87	1.00	0.91
Process Fraction of Available Water (PF_{AW})	0.83	0.73	0.80	0.80	0.71	0.76	0.45	0.35	0.41	0.75	0.80	0.77
Process Fraction of Available Water for Agriculture (PF_{AW-ag})	0.78	0.86	0.81	0.70	0.84	0.74	0.60	0.56	0.58	0.74	0.89	0.78
Process Fraction of Depleted Water (PF_{TD})	0.86	0.74	0.82	0.86	0.72	0.81	0.49	0.36	0.43	0.87	0.80	0.85
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.96	0.99	0.97	0.93	0.98	0.95	0.92	0.99	0.95	0.87	1.00	0.91

• Table 5 Water Accounting Data and Calculated Indicators for the Lower Bang Pakong River Basin (1994 = normal)

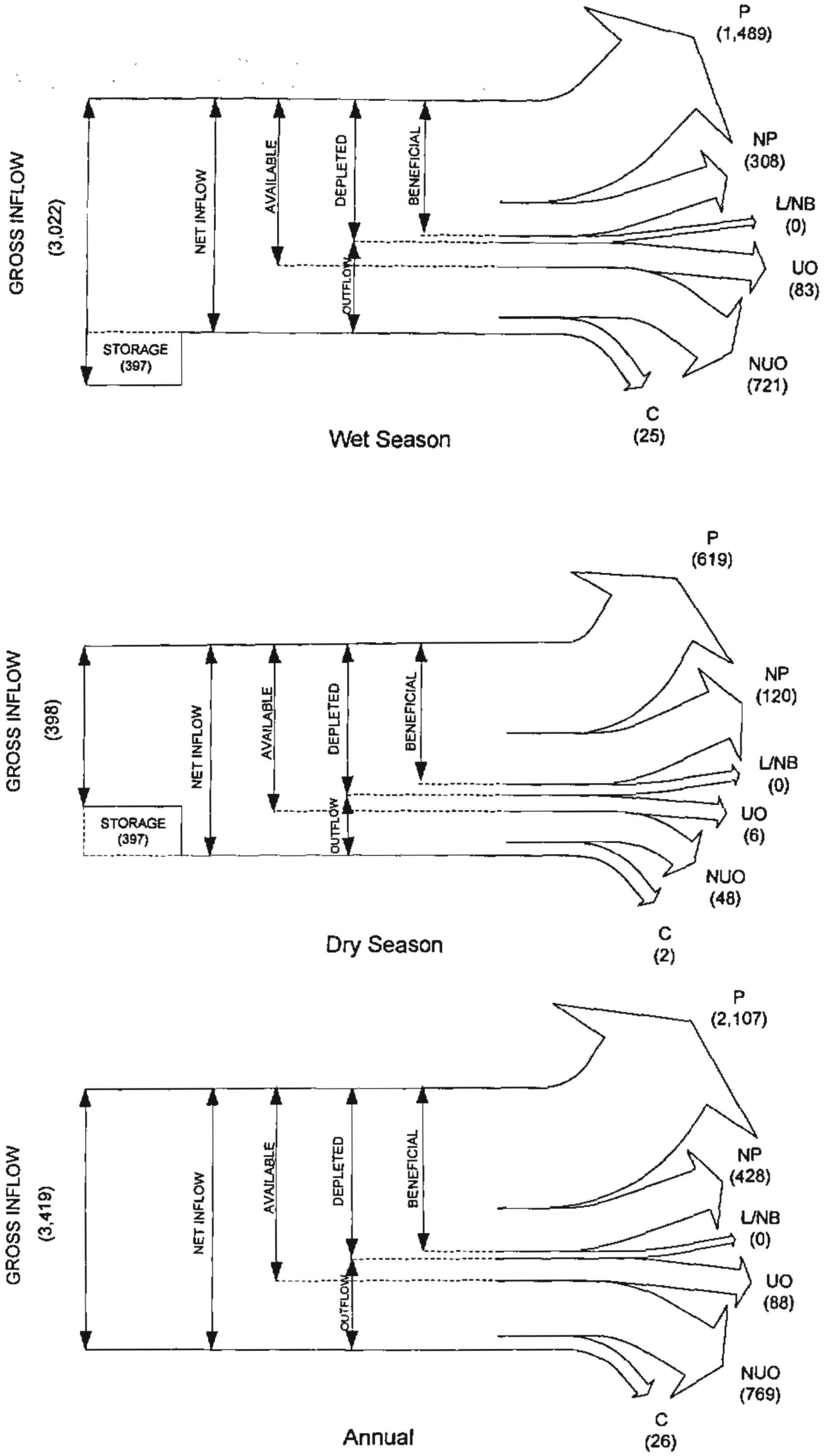
Items	Nakhon Nayok			Khlong Luang			Main Bang Pakong+Talat		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	2,939.8	334.1	3,273.9	1,864.3	445.7	2,309.9	10,070.3	503.4	10,573.6
Surface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	5,306.8	50.4	5,357.2
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	2,939.8	334.1	3,273.9	1,864.3	445.7	2,309.9	4,763.5	453.0	5,216.5
Net Inflow	2,211.7	1,062.2	3,273.9	1,618.8	691.2	2,309.9	8,417.3	2,156.3	10,573.6
Gross Inflow	2,939.8	334.1	3,273.9	1,864.3	445.7	2,309.9	10,070.3	503.4	10,573.6
ΔStorage	728.1	-728.1	0.0	245.5	-245.5	0.0	1,653.0	-1,653.0	0.0
Net Inflow	2,211.7	1,062.2	3,273.9	1,618.8	691.2	2,309.9	8,417.3	2,156.3	10,573.6
Depleted Water	1,329.7	1,040.5	2,370.2	1,279.0	684.9	1,963.9	2,242.4	2,065.2	4,307.6
Process Water	987.8	795.4	1,783.1	1,180.4	628.3	1,808.7	1,852.1	1,582.3	3,434.4
Water uses intended by humans	1.1	1.1	2.1	3.4	3.4	6.8	2.1	2.1	4.1
Evapotranspiration by crops (ET)	955.9	792.7	1,748.6	1,170.8	620.3	1,791.1	1,823.6	1,559.6	3,383.1
Evaporation from municipal and industrial uses (M&I)	1.3	1.3	2.7	4.3	4.2	8.5	2.6	2.6	5.2
Beneficial Non-process Water	339.2	242.0	581.2	62.8	32.4	95.2	363.7	452.5	816.2
Low or Non-beneficial Non-process Water	2.7	3.2	6.0	35.8	24.3	60.0	26.6	30.4	57.0
% Compare with Rainfall	1.0	0.1	0.9	0.1	0.1	0.1	0.5	4.0	0.8
Flows to sinks	29.4	0.3	29.7	1.9	0.4	2.3	23.8	18.1	41.9
Available Water	1,417.9	1,042.7	2,460.6	1,312.9	685.6	1,998.5	2,859.9	2,074.3	4,934.2
Outflow (VP)	1,612.3	20.2	1,632.5	336.3	8.8	345.1	6,661.1	97.8	6,759.0
% Compare with VP	54.7	107.1	55.4	101.0	71.3	100.3	92.7	93.2	92.7
Outflow	882.0	21.6	903.7	339.8	6.2	346.1	6,174.8	91.2	6,266.0
Uncommitted Outflow	855.6	21.0	876.6	329.6	6.1	335.7	5,989.6	88.4	6,078.0
Utilizable Outflow	88.2	2.2	90.4	34.0	0.6	34.6	617.5	9.1	626.6
Non-utilizable Outflow	767.4	18.8	786.2	295.6	5.4	301.1	5,372.1	79.3	5,451.4
Committed Outflow	26.5	0.6	27.1	10.2	0.2	10.4	185.2	2.7	188.0
Depleted Fraction of Gross Inflow (DF_{GI})	0.45	3.11	0.72	0.69	1.54	0.85	0.22	4.10	0.41
Depleted Fraction of Available Water (DF_{AW})	0.94	1.00	0.96	0.97	1.00	0.98	0.78	1.00	0.87
Process Fraction of Available Water (PF_{AW})	0.70	0.76	0.72	0.90	0.92	0.91	0.65	0.76	0.70
Process Fraction of Available Water for Agriculture (PF_{AW-ag})	0.79	0.89	0.83	0.92	0.94	0.93	0.69	0.87	0.76
Process Fraction of Depleted Water (PF_{TD})	0.74	0.76	0.75	0.92	0.92	0.92	0.83	0.77	0.80
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.94	0.99	0.96	0.95	0.96	0.95	0.77	0.98	0.86

• Table 6 Water Accounting Data and Calculated Indicators for the Lower Bang Pakong River Basin (1995 = wet)

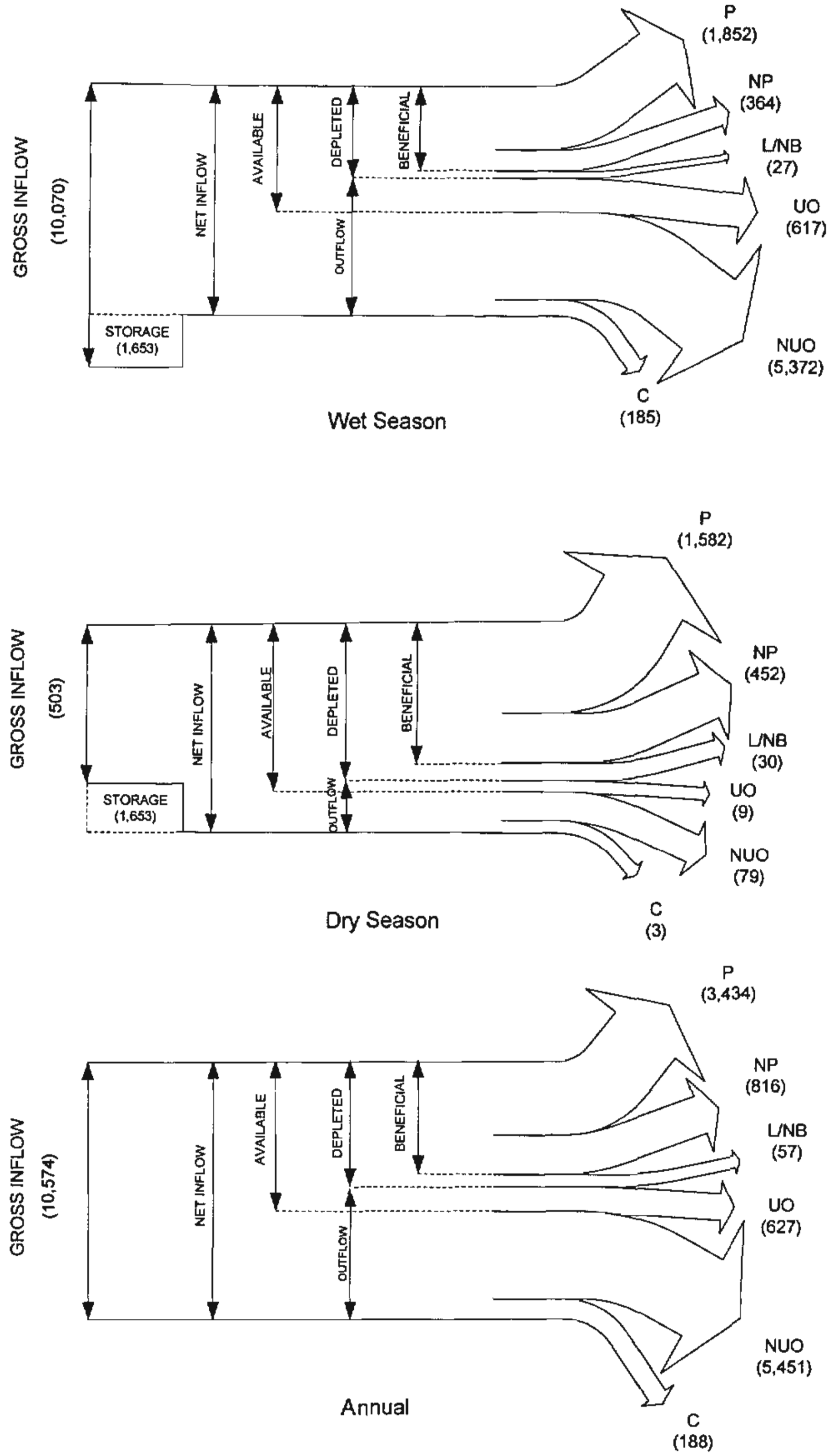
Items	Nakhon Nayok			Khlong Luang			Main Bang Pakong+Talat		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	3,850.7	372.5	4,223.2	2,098.9	445.1	2,544.0	11,679.0	545.1	12,224.1
Surface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	6,440.0	31.9	6,471.9
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	3,850.7	372.5	4,223.2	2,098.9	445.1	2,544.0	5,239.0	513.2	5,752.1
Net Inflow	3,059.8	1,163.4	4,223.2	1,846.9	697.1	2,544.0	9,970.1	2,254.0	12,224.1
Gross Inflow	3,850.7	372.5	4,223.2	2,098.9	445.1	2,544.0	11,679.0	545.1	12,224.1
ΔStorage	790.9	-790.9	0.0	251.9	-251.9	0.0	1,708.9	-1,708.9	0.0
Net Inflow	3,059.8	1,163.4	4,223.2	1,846.9	697.1	2,544.0	9,970.1	2,254.0	12,224.1
Depleted Water	1,893.2	1,143.0	3,036.1	1,308.5	689.7	1,998.2	2,415.4	2,153.7	4,569.2
Process Water	1,409.9	568.5	1,978.4	1,206.2	625.0	1,831.2	1,990.7	1,669.4	3,660.0
Water uses intended by humans	1.1	1.1	2.2	3.7	3.6	7.3	1.4	1.3	2.7
Evapotranspiration by crops (ET)	1,368.8	565.6	1,934.4	1,195.9	616.4	1,812.3	1,961.4	1,420.0	3,381.4
Evaporation from municipal and industrial uses (M&I)	1.4	1.4	2.8	4.6	4.5	9.1	1.7	1.7	3.4
Beneficial Non-process Water	480.5	571.3	1,051.8	66.5	40.5	107.0	396.8	452.5	849.3
Low or Non-beneficial Non-process Water	2.7	3.2	6.0	35.8	24.3	60.0	28.0	31.9	59.8
% Compare with Rainfall	1.0	0.1	0.9	0.1	0.1	0.1	0.5	48.0	4.7
Flows to sinks	38.5	0.4	38.9	2.1	0.4	2.5	26.2	246.3	272.5
Available Water	2,009.8	1,145.0	3,154.8	1,362.3	690.5	2,052.8	3,170.9	2,163.8	5,334.7
Outflow (VP)	1,612.3	20.2	1,632.5	336.3	8.8	345.1	6,661.1	97.8	6,759.0
% Compare with VP	72.4	101.2	72.7	160.1	83.6	158.2	113.4	102.5	113.3
Outflow	1,166.6	20.5	1,187.1	538.5	7.3	545.8	7,554.6	100.3	7,654.9
Uncommitted Outflow	1,131.6	19.8	1,151.5	522.3	7.1	529.4	7,328.0	97.2	7,425.2
Utilizable Outflow	116.7	2.0	118.7	53.8	0.7	54.6	755.5	10.0	765.5
Non-utilizable Outflow	1,015.0	17.8	1,032.8	468.5	6.4	474.8	6,572.5	87.2	6,659.7
Committed Outflow	35.0	0.6	35.6	16.2	0.2	16.4	226.6	3.0	229.6
Depleted Fraction of Gross Inflow (DF_{GI})	0.49	3.07	0.72	0.62	1.55	0.79	0.21	3.95	0.37
Depleted Fraction of Available Water (DF_{AW})	0.94	1.00	0.96	0.96	1.00	0.97	0.76	1.00	0.86
Process Fraction of Available Water (PF_{AW})	0.70	0.50	0.63	0.89	0.91	0.89	0.63	0.77	0.69
Process Fraction of Available Water for Agriculture (PF_{AW-ag})	0.80	0.71	0.77	0.91	0.94	0.92	0.67	0.75	0.70
Process Fraction of Depleted Water (PF_{TD})	0.74	0.50	0.65	0.92	0.91	0.92	0.82	0.78	0.80
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.94	1.00	0.96	0.93	0.96	0.94	0.75	0.98	0.85

• Table 7 Water Accounting Data and Calculated Indicators for the Lower Bang Pakong River Basin (1996 = dry)

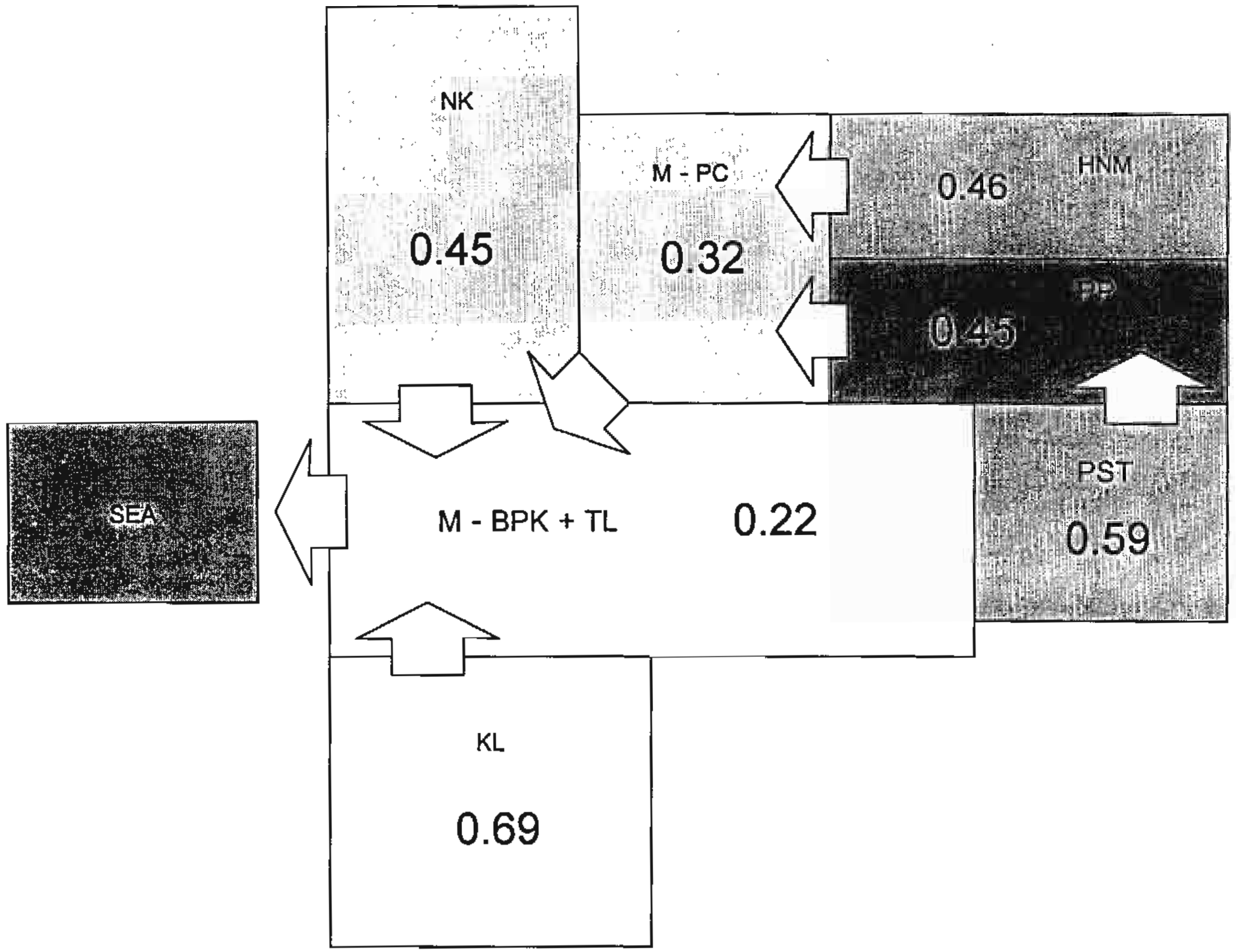
Items	Nakhon Nayok			Khlong Luang			Main Bang Pakong+Talat		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
Gross Inflow	2759.0	411.8	3170.8	2310.1	288.8	2598.9	8765.4	791.5	9556.9
Surface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	4742.2	76.7	4818.8
Sub-Surface Inflow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation	2759.0	411.8	3170.8	2310.1	288.8	2598.9	4023.2	714.8	4738.0
Net Inflow	2012.3	1158.5	3170.8	2055.0	543.8	2598.9	7103.1	2453.8	9556.9
Gross Inflow	2759.0	411.8	3170.8	2310.1	288.8	2598.9	8765.4	791.5	9556.9
ΔStorage	746.7	-746.7	0.0	255.1	-255.1	0.0	1662.3	-1662.3	0.0
Net Inflow	2012.3	1158.5	3170.8	2055.0	543.8	2598.9	7103.1	2453.8	9556.9
Depleted Water	1267.7	1127.6	2395.4	1227.4	541.4	1768.7	2359.9	2188.8	4548.7
Process Water	925.8	586.7	1512.5	1147.3	458.6	1605.9	1935.2	1704.4	3639.6
Water uses intended by humans	1.2	1.2	2.4	3.9	3.8	7.6	2.2	2.2	4.5
Evapotranspiration by crops (ET)	895.5	583.6	1479.1	1136.3	449.8	1586.1	1910.0	1356.3	3266.3
Evaporation from municipal and industrial uses (M&I)	1.5	1.5	3.0	4.8	4.7	9.6	2.8	2.8	5.6
Beneficial Non-process Water	339.2	537.7	876.9	44.3	44.5	88.9	396.8	452.5	849.3
Low or Non-beneficial Non-process Water	2.7	3.2	6.0	35.8	38.2	74.0	28.0	31.9	59.8
% Compare with Rainfall	1.0	0.1	0.9	0.1	0.1	0.1	0.5	48.0	7.7
Flows to sinks	27.6	0.4	28.0	2.3	0.3	2.6	20.1	343.1	363.2
Available Water	1342.2	1130.7	2472.9	1310.1	541.6	1851.8	2834.3	2215.3	5049.6
Outflow (VP)	1612.3	20.2	1632.5	336.3	8.8	345.1	6661.1	97.8	6759.0
% Compare with VP	46.2	152.6	47.5	246.1	28.2	240.6	71.2	270.9	74.1
Outflow	744.6	30.8	775.4	827.6	2.5	830.1	4743.2	265.0	5008.1
Uncommitted Outflow	722.2	29.9	752.1	802.8	2.4	805.2	4600.9	257.0	4857.9
Utilizable Outflow	74.5	3.1	77.5	82.8	0.2	83.0	474.3	26.5	500.8
Non-utilizable Outflow	647.8	26.8	674.6	720.1	2.1	722.2	4126.5	230.5	4357.1
Committed Outflow	22.3	0.9	23.3	24.8	0.1	24.9	142.3	7.9	150.2
Depleted Fraction of Gross Inflow (DF_{GI})	0.46	2.74	0.76	0.53	1.87	0.68	0.27	2.77	0.48
Depleted Fraction of Available Water (DF_{AW})	0.94	1.00	0.97	0.94	1.00	0.96	0.83	0.99	0.90
Process Fraction of Available Water (PF_{AW})	0.69	0.52	0.61	0.88	0.85	0.87	0.68	0.77	0.72
Process Fraction of Available Water for Agriculture (PF_{AW-ag})	0.79	0.72	0.76	0.89	0.89	0.89	0.74	0.70	0.72
Process Fraction of Depleted Water (PF_{TD})	0.73	0.52	0.63	0.93	0.85	0.91	0.82	0.78	0.80
Beneficial Utilization of Available Water or Basin Efficiency (BU or BE)	0.94	0.99	0.97	0.91	0.93	0.92	0.82	0.97	0.89



• Figure 5 Water Accounting Diagram of the Khlong Pra Satung Sub Basin in Normal Year (1994)



• Figure 6 Water Accounting Diagram of the Main Bang Pakong and Talat Sub Basin in Normal Year (1994)



• Figure 7 Water Indicator Diagram of the Depleted Fraction of Gross Inflow (DF_{GI}) of Wet Season in Normal Year (1994)

Chapter

3

Socio-Economic Analysis

This section documents the results from the socio-economic research component for the Bang Pakong River Basin located in eastern Thailand. The study sets out to build a general description of the socio-economic profile of the river basin, to develop performance indicators for irrigation, and to draw lessons to link with the results from the institutional analysis and water accounting research components. The results of the study give an indication of who are the important stakeholders within the basin, what role they play in the water management decision-making process, what is their relative influence level, and what is the current state of irrigation water use in the basin. The socio-economic profile and performance indicators will greatly aid the process of crafting effective water management institutions for the Bang Pakong River Basin. This section offers a broad overview of the socio-economic situation, an assessment of irrigation performance, and a general institutional setting for the two basins. This section also offers an analysis of the linkages between the water accounting and institutional analysis components of the study.

Macroeconomic and Socio-economic characteristics[3]

Thailand has been one of the more successful developing countries over the past few decades. Its GDP grew at an average annual rate of 7.6 percent during the 1980s. From 1980 to 2000, agriculture dropped from 23.2 percent to 10.5 percent as a component of GDP, while industry climbed from 28.7 percent to 40.1 percent (World Bank, 2002). Approximately 40 percent of the total labor is employed in agricultural activities (Bank of Thailand, 2002). The poverty rate in 1999 stood at 16 percent measured as US$ 1.50 per day.

Employment in Thailand is largely based on agriculture with nearly 40 percent of the labor force employed in agricultural activities. However, in 2000, agriculture accounted for only 10.5% of Thailand's GDP. Thailand's GDP per capita for the year 2000 was reported as US$ 1,788 (Bank of Thailand, 2002). According to World Bank statistics, the population of Thailand was 60.7 million people in 2000 with a population growth rate of 0.8 percent annually. Using a poverty line of $1.50 per day, the poverty rate for all of Thailand in 1999 was 16 percent.

In 1997, Thailand was hit by the financial crisis that caused a dramatic increase in unemployment. While Thailand has undertaken several economic restructuring initiatives to address causes of the crisis, there remain several risks to the future of the Thai economy. Chief among these is the strong reliance of the Thai economy on exports. While the global slowdown appears to be abating, entry in the WTO by China will provide strong competition for Thai businesses (Maneerungsee, 2002). Overall, while Thailand has taken great strides in strengthening it administrative structure and economic base, there are still great challenges ahead. It will become ever more critical that Thailand maintains its advantages and resources.

[3] Statistics in this section that are not cited are from the World Bank's "Thailand at a Glance" fact sheet, 2002.

National Policy/Legal Setting[4]

The institutions, policies, and laws are almost exclusively at the national level. However, there is a general lack of coordination between the various ministries, policies, budgets, etc. (see the section on Institutional Analysis). The National Water Resources Committee has been established by the Prime Mister to coordinate the numerous agencies involved with water management. In 2000, the ONWRC working in consultation with other stakeholders developed a national water policy that was approved by the National Cabinet of Thailand. The water policy calls for increased efforts to approve a Draft Water Act to guide national water management, develop river basin organizations, and promote a participatory approach to water management. Many of the current directions in water management have been influenced by the 1997 Constitution, which calls for a more decentralized and participatory approach to the management of water resources.

However, to date the policy environment remains ineffective due to a lack of coordinated planning mechanism and a national water law. This leaves each agency to fend for its own self-interest at the expense of efficient water management. Furthermore, the process that is in place is strongly top-down, which creates ineffective linkages between national and local levels. The establishment of RBOs in Thailand's river basin should help to alleviate this problem, as members will be drawn from government, non-government, and farmer water user groups. The current Draft Water Resources Act still lacks an effective conflict resolution procedure and fails to assign the ONWRC strong powers of authority.

Brief Description of Development Plans for the Bang Pakong River Basin

A plan has been devised to build several upstream storage reservoirs to better regulate the flow of water in the river. However, opposition based on environmental impacts has greatly reduced the likelihood of these dams ever being constructed. Problems in the basin are soil erosion along the banks with conflicting opinions about whether it has been exacerbated because of the diversion dam. Salinity intrusion during the dry season poses a problem for some farmers, while others have adapted by choosing to grow crops that benefit from the saline water. Other characteristics are that the Bang Pakong must take water from the Chao Phraya for dry season supplies and provide flood protection for Bangkok.

Management of water resources in the Bang Pakong River Basin

In 2001, the Office of the National Water Resources Committee established the Bang Pakong River Basin Committee. This Basin Committee has the responsibility to manage water resources in the Bang Pakong-Prachinburi River Basins. Currently, there are two key agencies involved with the management of surface water resources. These are the Royal Irrigation Department (RID) and the East Water Resources Development and Management Public Company. The RID conducts operations to insure water supply for agriculture, industry, and public utilities. The East Water Resources Development and Management Public Company manage water resources, especially raw water, transmission systems for industrial and consumer use.

In actual current practice, the RID is the main water management agency for the Bang Pakong Basin. They base water deliveries on estimated demand requirement. This is particularly pressing in the dry season, when water delivery is constrained by water stored in the dam. Factors affecting delivery include requirements for transportation, salinity control, and crop requirements. There are several conflicts within the basin, but there is no effective means for

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[4] The separate report for the Institutional Analysis should be referred to for a comprehensive and thorough analysis of the institutional and legal setting.

resolving the conflicts. This problem may ease as the River Basin Committee grows in experience and influence.

Demographic Characteristics of the Bang Pakong River Basin

The basin is characterized by high amounts of agricultural activity. Approximately 77 percent of the land area of the basin is classified as agricultural. There is a significant upward in population trend as one moves from upstream to downstream (see Table 8). Population for the basin is primarily rural in classification. The poverty rate is high throughout the basin ranging from 45 percent to 85 percent. The proportion of rural poor who are female is consistent throughout the basin at about 50 percent. Interestingly, the percentage of poor who are engaged in agriculture seems unusually low with a range from 13.1 percent to 29.7 percent. This may be a result of error in classifying occupations as agricultural or service.

• Table 8 General Socio-Economic Indicators of the Bang Pakong River Basin

Area Name	Population	Rural Population	Rural Poverty Rate	% of Poor that are female	% of Poor in Agriculture
Khlong Phra Sathung	251,013	241,254	45%	49.4	29.7
Khlong Phra Prong	172,133	164,034	80%	49.7	23.1
Mae Nam Hanuman	93,937	92,344	85%	50.3	26.3
Main Prachinburi	309,788	286,680	52%	49.9	17.3
Nakhon Nayok	233,409	215,636	54%	51.1	19.6
Khlong Luang	334,543	146,125	48%	50.2	13.1
Main Bang Pakong + Talat	474,129	421,599	52%	49.8	21.8

Socio-Economic Stakeholder Analysis

Information for the analysis of the different stakeholders is given in Table 9 below. The table ranks the various stakeholders in terms of relative wealth and relative influence in the decision making process. Relative wealth is related only to wealth within the basin and is independent of any poverty line. Relative influence is a measure of the influence that a particular stakeholder has on the decision-making process regarding water resources. As can be seen in the Table, irrigators are classified as both poor and low in influence. However, they are the largest bulk user of water in the basin. This indicates large potential for conflicts and inequitable outcomes as competition for scarce water resources intensifies. Interestingly, water user associations are classified as high in influence. During the field visits, it was stated that farmer water user groups have been encouraged to federate to increase their influence on the decision making process. All users are affected by seasonal water scarcities.

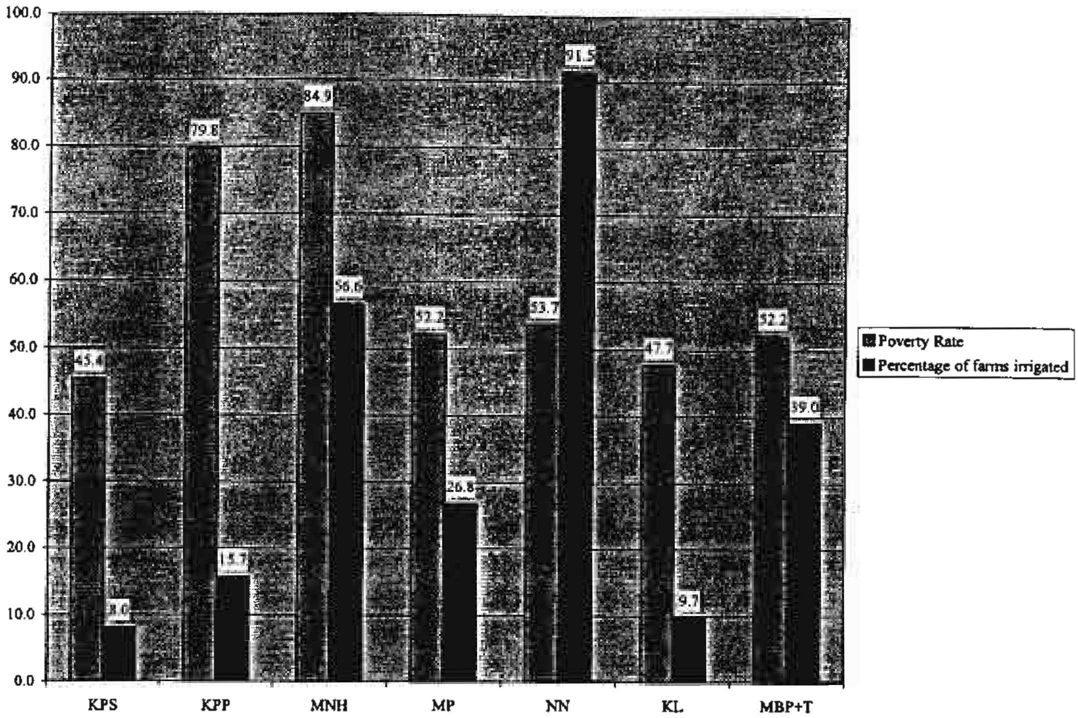
For the Bang Pakong River Basin, the environment is ranked as having high influence on the water management decision-making process. This can be seen to some degree in the decision to not construct several upstream reservoirs. The precise degree to which the decision to not construct was based on environment concerns rather than the lack of budget is not certain. However, environmental concerns were undoubtedly a major influence in the decision.

• Table 9 Stakeholder Analysis in the Bang Pakong River Basin

Stakeholder	User or Manager	Source of Water	Management level	Role in Management	Relative wealth position (poor/non-poor)	Relative influence position (high/low)	Suffer from water scarcity (yes/no/ seasonal)
Irrigators	User	canal systems	From Head regulator to Farm turnout	Allocation amounts and timing	poor	low	seasonal
Domestic Users	User	Reservoir/ Pumping	Project level, From Headwork through Users	Provide source and delivery water to user	non-poor	high	seasonal
Industry	User	Reservoir/ Pumping	Project level, From Headwork through Users	Provide source and delivery water to user	non-poor	high	seasonal
Environment	User	Reservoir/ Main river	-	-	-	high	seasonal
WUA	User	canal systems	On-farm	Request amount and timing	non-poor	high	seasonal
Government Management Board	Manager	Basin	National and Main Basin	Policy and guidelines	-	high	seasonal

Poverty Situation in the Bang Pakong River Basin

The rates of poverty in the sub-basin areas studied are very high relative to the national average of 16%. The rural poverty rates are between 45% and 85% for all sections. This seems to be a reflection of the lack of a large-scale irrigation project within the basin. According to the Master Plan for the Bang Pakong River Basin, RID has built or is planning to build 18 large irrigation projects. The projected irrigated area by these 18 projects is thought to be 1.4 million rai. There seems to be no correlation between the percentage of farms irrigated and the poverty rates (see Figure 8). As data showed a relatively low percentage of the poor engaged in agriculture, it is probable that irrigation may have a minimal impact on poverty. This is an important topic for further study if irrigation is sought as a means to alleviate poverty.



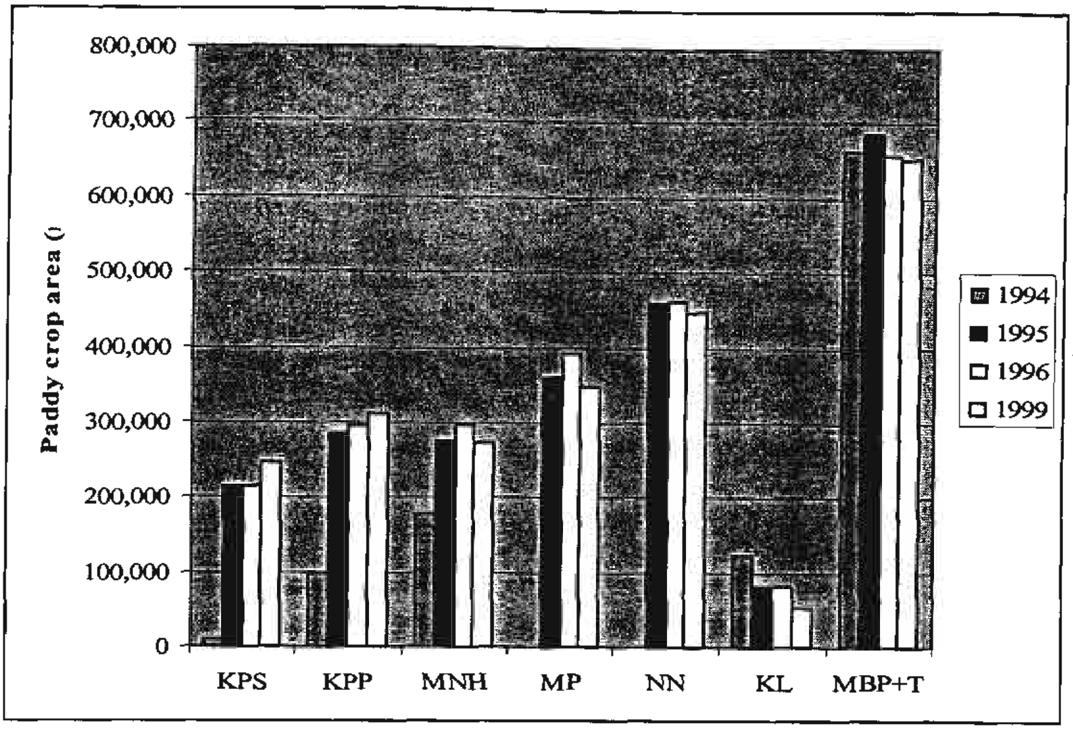
• Figure 8 Comparison of Poverty Rate vs. Percentage of Farms Irrigated Moving Downstream on the Bang Pakong

Agricultural description the Bang Pakong River Basin

Rice, maize, and cassava are the most significant crops grown in the basin in terms of land area (see Table 10). The major rice crop accounts for 54% of agricultural land in the basin with a fairly stable trend in cropped area (see Figure 9). Shrimp farming is becoming an increasingly important activity. As the income per rai is far higher than any crop, this raises the potential of an influential water user group that typically creates many negative externalities for other water users. Agriculture accounts for approximately 74% of land use within the basin (see Table 11). Khlong Luang has the lowest ratio of agricultural to total land use at 57%. Irrigation is most widely developed in the Nakhon Nayok sub-basin with 1.1 million rai receiving surface irrigation out of a possible 1.2 million rai of agricultural land.

• Table 10 Land area for each crop in the Bang Pakong River Basin (rai)

	KPS	KPP	MNH	MP	NN	KL	MBP+T
Major rice	246,729	312,368	272,956	347,416	446,772	53,866	651,624
Second rice	5,214	10,929	16,609	35,375	56,402	2,585	222,397
Maize	154,733	141,461	53,189	33,786	33,395	1,276	31,803
Cassava	110,248	97,634	56,573	65,408	3,106	123,479	351,352
Sugar cane	16,172	13,758	5,836	5,505	4,127	65,655	61,575
Soybean	24,856	23,048	8,298	6,108	2,225	83	12,423
Ground nut	1,833	2,053	3,998	5,272	984	1,023	1,705
Cotton	3,151	2,940	1,649	1,552	350	3	482
Pineapple	627	106	0	443	19	14,337	10,170
Shrimp	4,369	2,103	3,612	6,742	197	5,821	37,535

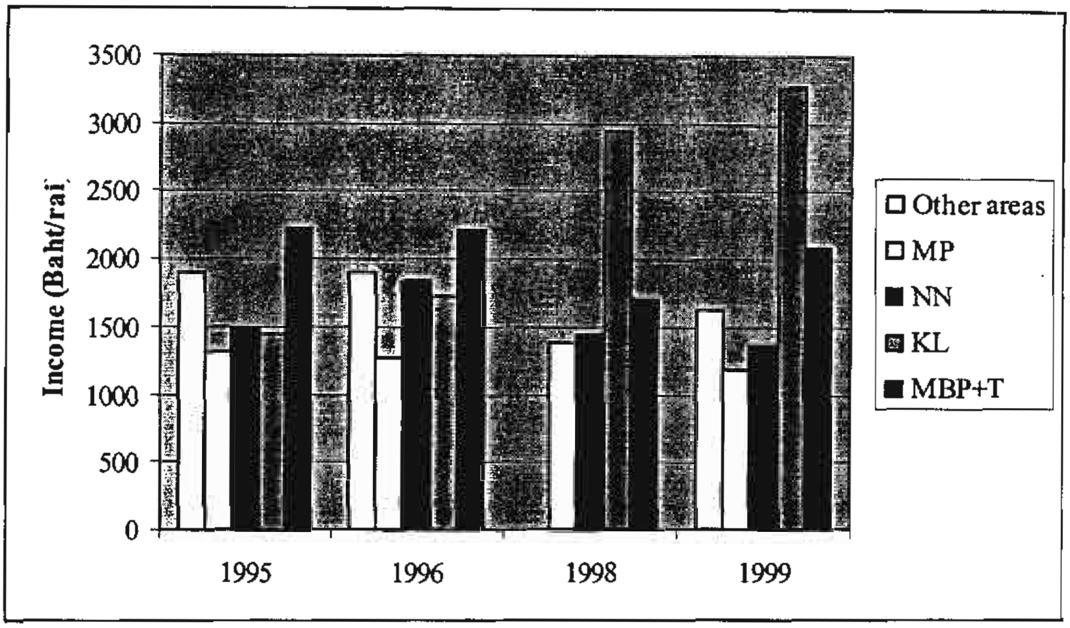


• Figure 9 Trend in Crop Area in Rai for Major Rice Moving from Upstream to Downstream on the Bang Pakong River Basin

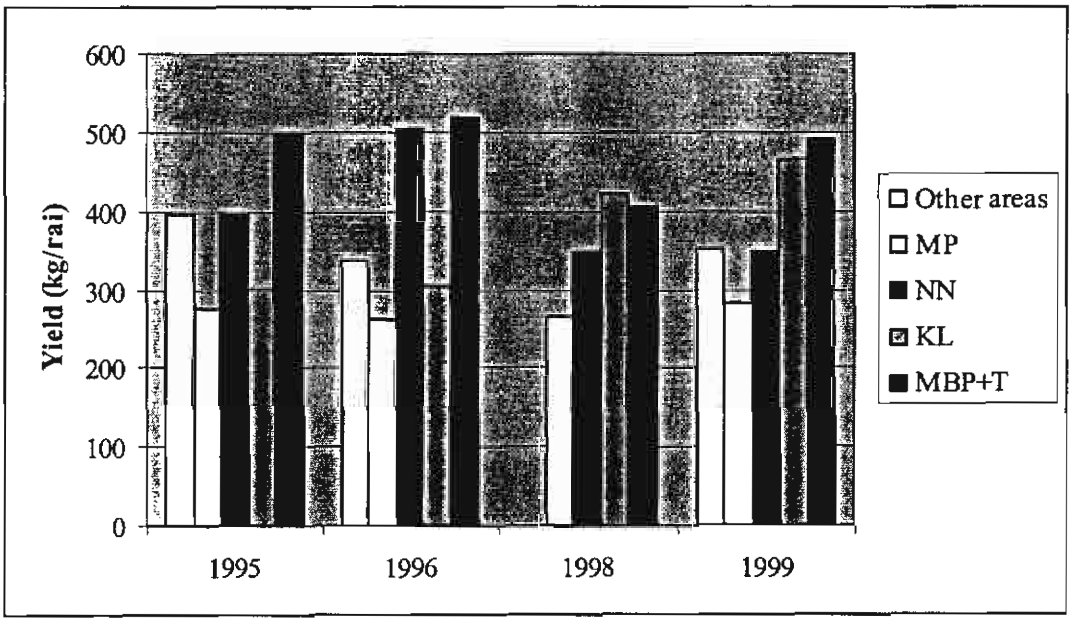
• Table 11 Agricultural Land Use in the Bang Pakong River Basin (1999)

Land Use		KPS	KPP	MNH	MP	NN	KL	MBP+T
Total	Rai	1,628,125	1,610,000	1,323,125	1,576,875	1,520,625	1,185,625	2,718,125
Agriculture	Rai	1,314,000	1,262,428	934,748	1,060,479	1,233,681	673,137	2,103,409
Forested	Rai	314,125	346,102	386,107	501,976	285,494	497,898	615,446
Reservoirs and Ponds	Rai	0	0	370	590	2,240	26,800	15,500
Urban	Rai	0	1,470	1,900	15,010	3,690	41,390	14,770
Agricultural land and irrigation								
Surface/canal	Rai	105,386	197,746	528,893	283,747	1,128,815	65,530	821,343
Groundwater	Rai	0	0	0	0	0	0	0
Rain-fed	Rai	1,208,614	1,064,682	405,855	776,732	104,866	607,607	1,282,066
Number of farms	Number	36,520	34,352	27,000	18,233	21,933	19,698	39,785
Average farm size	Rai	36	37	35	35	35	35	35
Percent of farms irrigated	%	8.0	15.7	56.6	26.8	91.5	9.7	39.0
Farmer land tenure situation								
Own	Number	135,088	74,033	35,926	110,355	69,754	153,074	223,756
Rent	Number	7,518	10,119	5,396	19,665	30,636	20,702	44,857
Landless	Number	0	0	0	0	0	0	0
Farm Income								
Average income	(Baht/year)	39,792	27,559	25,588	n/a	60,087	78,858	49,277

Trends in income from growing paddy were examined for certain provinces as presented in Figure 10. The graph shows an increasing trend in income from paddy for the Khlong Luang area, while the other areas are experiencing a decline in the income (in Baht/rai) from paddy. Khlong Luang is home to Chonburi and has the highest level of urban land use at over 41,000 rai. Proximity to a large urban market could explain this rise in income from paddy, particularly if the urban areas are growing quickly in population. Furthermore, Khlong Luang is experiencing a rise in yields for paddy as shown in Figure 11. This may be a result of less productive lands being taken out of production causing the average to rise.



• Figure 10 Trend of Income from Major Rice in the Bang Pakong River Basin (Baht/Rai)



• Figure 11 Trend in Yields for Major Paddy Crop in the Bang Pakong River Basin

Irrigation Performance in the Bang Pakong River Basin

Indicators of irrigation performance were calculated based on methodology developed by IWMI.[5] The data and calculated irrigation performance indicators are given in Table 12 below. In the Mae Nam Hanuman and Main Prachinburi Sub-basins, there are no reservoirs and so are not described in the table. The source of data is from research reported in 1996. At Khlong Sam Sib reservoir, there are different values between the irrigated area and command area because the one part of this area received water from another reservoir. The total O&M expenses per cubic meter were estimated from annual water development and services cost. The gross value of output in local currency is the total income from agricultural and non-agricultural activities; however, non-agricultural income could be negligible compared to agricultural income. The estimation of this value is the summation of the products of price and area for all crops in the each reservoir.

The irrigation systems examined are a small sampling of representative irrigation systems within the Bang Pakong River Basin. The most striking feature is that no irrigation revenues are reported. General practice of irrigation management in Thailand does not include the collection of irrigation fees from farmers. This situation can create several problems for the irrigators and irrigation management. First, financial sustainability is not possible under the current conditions. The irrigation system will be completely dependent on government financing to remain operational. Second, dependence upon the government for operation financing weakens their bargaining position within the water management process. Dialogue with various key experts indicated that a reversal of this practice is highly unlikely in the near term. A reluctance to charge and collect water fees all removes an instrument to help regulate the use of water.

Relative water supply is significantly above unity for all systems, while relative irrigation supply is negative. The high values for relative water supply are indicative of the high amounts of rainfall received on an annual basis. It is expected that these figures would vary drastically if calculated on a seasonal basis. These high numbers all represent the potential for beneficial use of increased storage facilities in the basin. Of course, a final decision must consider the impacts of additional storage on all stakeholders. The negative relative irrigation supply is also a result of the relatively high amounts of annual rainfall received. In essence, annual rainfall surpasses crop water demand. While on the surface this would seem to indicate that irrigation is not needed, issues of timing of rainfall and lack of storage must be considered. Finally, the divergence of output per unit of irrigation water and output per unit of available water indicate the high degree of rainfall that goes unused.

Competition and Conflicts for Water in the Bang Pakong River Basin

There are several conflicts that currently exist in the Bang Pakong River Basin. These are summarized in the Table in Annex 7. Among these, the most apparent surrounds the Bang Pakong Diversion Dam, which is at the center of many conflicts. These conflicts include the need for additional storage reservoirs in the upstream sections, the balance between salinity control and desire for saline water in the coastal regions, water quality issues, and claims of increased riverbank erosion.

Additionally there are inter-basin issues since the Bang Pakong receives water from the Chao Phraya during the dry season and provides flood protection for Bangkok during the rainy season. While all of these conflicts have been identified, there remains the lack of a well-coordinated and effective system for resolving these matters. The newly formed River Basin Committees will in time act in such a manner; however, they currently lack the experience and

[5] To date, remaining difficulties cast doubt on the reliability of data presented for gross value of production. However, the data are presented here for completeness sake and should be considered indicative only.

legitimacy to effectively carry out their responsibilities. It is important that the River Basin Committees being given the full support of the government in order for them to become the effective water resource management institutions they were designed to be.

Conclusions and Discussion

This analysis has offered a general profile of the socio-economic situation in the Bag Pakong River Basin. Additionally, the report offers an analysis of the performance of irrigation within the basin. The results of the analysis show that in general an improvement in the management of water resources can hold significant benefits for society. For example, there are several conflicts involving water quality, that if resolved would benefit all water users. However, if left unresolved the water quality could continue to deteriorate exerting tremendous costs on society when the issues can no longer be ignored

The conclusions of this report will be strengthened by linking to the material in the Institutional Analysis and Water Accounting studies done for the overall project. These linkages are reported in a synthesis report prepared for the study. The results of the socio-economic study strengthen the call for an improved water management framework and institutions. While less than optimal water resource management may result from a weak institutional structure, poor water resource management may also have negative impacts on the socio-economic aspects of the basin. These negative impacts may amplify and feedback existing problems and conflicts with water management.

• Table 12 Irrigation Performance Indicators in the Bang Pakong River Basin

Name of Basin and Sub-Basin Area		Khlong Phra Sathung	Khlong Phra Prong				Nakhon Nayok			Khlong Luang	Main Bang Pakong + Tolat
Irrigation System or Sub-system		Khlong Sam Sib Reservoir	Huay Chan Reservoir	Khlong Krear Reservoir	Tha Kra Bark Reservoir	Khlong Pan Po Reservoir	Khlong Bhod Reservoir	Srai Thong Reservoir	Huay Prae Reservoir	Ban Beung Reservoir	Lad Kra Ting Reservoir
Gross value of Output in Local Currency	Baht	4,175,490	8,625,600	6,553,860	8,679,120	6,095,600	2,044,390	2,057,890	4,065,980	10,870,020	11,037,080
Irrigated Area.	rai	2,680	4,000	3,000	4,000	2,800	1,000	1,000	2,000	2,000	1,500
Command Area.	rai	2,200	4,000	3,000	4,000	2,800	1,000	1,000	2,000	3,000	1,500
Diverted Irrigation Supply	mcm	0.94	3.04	2.96	3.59	2.06	0.03	0.02	1.9	2.59	1.22
Annual Rainfall (Approximately)	m^3	7,019,456	10,476,800	7,857,600	10,476,800	7,333,760	2,316,800	2,316,800	4,633,600	4,633,600	3,475,200
Rainfall	mm	1,637	1,637	1,637	1,637	1,637	1,448	1,448	1,448	1,448	1,448
Crop Water Demand	mcm/year	0.297	3.04	3.04	3.59	2.43	0.027	0.024	1.903	2.992	1.216
Total Water Supply	mcm/year	4.30	13.17	4.39	6.73	13.37	1.14	12.44	9.11	14.09	5.66
Total Irrigation Supply	mcm/year	5.57	3.10	4.25	4.75	0.22	4.05	1.70	7.70	9.25	4.15
Total O & M Expenditure	Baht/rai/year	241.58	95.79	175.10	146.78	2.64	98.04	146.2	331.1	397.75	237.93
Revenue From Irrigation	Bath/rai/year	0	0	0	0	0	0	0	0	0	0

Output per unit of cultivated area	Baht/rai/year	1,558	2,156	2,185	2,170	2,177	2,044	2,058	2,033	5,435	7,358
Output per unit of command area	Baht/rai/year	1,898	2,156	2,185	2,170	2,177	2,044	2,058	2,033	3,623	7,358
Output per unit of irrigation water	Baht/m^3	4.44	2.84	2.21	2.42	2.96	68.15	102.89	2.14	4.20	9.05
Output per unit of available water	Baht/m^3	0.59	0.82	0.83	0.83	0.83	0.88	0.89	0.88	2.35	3.18
Relative water supply	-	42.39	4.47	3.98	4.24	3.11	235.81	167.37	6.48	4.64	6.27
Relative irrigation supply	-	-0.83	-0.42	-0.88	-0.69	-0.04	-1.77	-0.74	-2.82	-5.63	-1.84
Financial Self-sufficiency	-	0	0	0	0	0	0	0	0	0	0

Chapter

4

Institutional Analysis

Thailand has an abundance of water and other natural resources, ideal climate and progressive rural population. Its climate is monsoonal with the majority of the precipitation occurring during the rainy season from May through to October. Water resources have traditionally been used for rice growing centered in the lower plains of the Chao Phraya basin. Water is seen to be a 'common good' and there has traditionally been free access. No problems existed with this approach when water was plentiful and with little upstream-downstream or cross-sectoral competition for water. However, the rapid expansion of the Thai economy in recent times has dramatically changed this previously "comfortable" state of water availability to the extent that there is now real competition for water in the dry season and shortages and restrictions are not uncommon. Behind this expansion is the:

1) Growth in the demand for domestic consumption of water in the urban area.

2) Increases in demand for upstream irrigation to increase agricultural production.

3) Increasing demand for surface and groundwater for industrial development affecting both the quantity and quality of the lower basin resources.

4) Increase in demand outside irrigated area.

5) Sea intrusion especially in the estuary and nearby area.

Among these rapid changes, a firm organization and mechanism is needed in order to counter all the negative effect and provide opportunity for sustainable development. This institutional analysis tries to identify the framework and development of water resources management in Bang Pakong River Basin under the national context and also to analyze the existing organization and mechanism both at national and river basin levels.

Policy, Organisation and Legal Instrument at National Level

A number of government agencies are involved in water resources management and use in Thailand (see Annex 8). At the national level there are four major boards and committees, which are responsible for policy planning and coordination of water resources. The three most dominant ministries in terms of water management are Agriculture and Cooperatives (MOAC), Science Technology and Environment (MOSTE), and Industry (MOI). Consequently it makes things more complicated and confusing resulting in work duplications and lack of appropriate owner of work in some situations.

Water resources management in Thailand also encounters with other problems namely:

1) Policy and plan, there is no unity policy setting by all agencies concerned. The existing plans do not systematically cover all development aspects and lack participation from related parties at all levels.

2) Budgeting, at present budget is allocated to each agency upon their requests. In such process, it lacks the method for problem-solving in each area as a whole and causes less effective implementation. This is also the problem faced in water resources management.

3) Legal framework, there are several acts concerning water resources but not even one directly relates to water resources management. Therefore, it is necessary to draft such a law that can react properly to increasing problems or requirements.

4) Available information, because of too many implementing agencies, information on water resources development scatters all around. This makes it difficult to plan for efficient programs in water development. In addition, it is hard to formulate new projects under Organization such circumstance.

Under Office of the Prime Minister's Regulation on National Water Resources Management, 1989 National Water Resources Committee (NWRC) was established with an aim to be an apex body. It will take leading role in coordinating all concerned agencies in planning and systematizing an information system in order to create an effective water resources management. However, this goal was not achieved easily considering lacking of permanent organisation to support the work of NWRC. Therefore, Office of the National Water Resources Committee (ONWRC) was legally set up in late 1996. Annex 9 shows mandate and composition of NWRC and Annex 10 – ONWRC's structure.

In collaboration manner, ONWRC and other agencies concerned formulated national water vision in 1999. Shortly after that national water policy was further dirived by consultation with other stakeholders and was approved by the Cabinet in 2000.

National Water Vision

By the year 2025, Thailand will have sufficient water of good quality for all users through an efficient management, organizational and legal system that would ensure equitable and sustainable utilization of its water resources with due consideration on the quality of life and the participation of all stakeholders.

National Water Policy

1) Accelerate the promulgation of the Draft Water Act to be the framework for national water management by reviewing the draft and implementing all necessary steps to have the act effective, including reviewing existing laws and regulations.

2) Create water management organizations both at national and river basin levels with supportive laws. The national organization is responsible for formulating national policies. Monitoring and coordinating activities to fulfill the set policies. The river basin organizations are responsible for preparing water management plans through a participatory approach.

3) Emphasize suitable and equitable water allocation for all water use sectors, and fulfill basic water requirements in agriculture and domestic uses. This will be accomplished by establishing efficient and sustainable individual river basin water use priorities under clear water allocation criteria, incorporating beneficiaries' cost sharing based on ability to pay and level services.

4) Formulate clear directions for raw water provision and development compatible with the basins' potentials and demands, and ensuring suitable quality while conserving the natural resources and maintaining the environment.

5) Provide and develop raw water resources for farmers extensively and equitably in response to water demand for sustainable agricultural and domestic uses, similar to deliveries of other government basic infrastructure services.

6) Include water related topics at all levels of educational curriculum so as to create awareness for water value, understanding the importance of efficient water utilization, necessity and responsibility in maintaining natural and man made water sources.

7) Promote and support participation, including clear identification of its procedures, clear guidelines on right and responsibility of the public, non-government and government organizations in efficient water management. The water management includes water utilization, water source conservation, monitoring and preservation of water quality.

8) Accelerate preparation of plans for flood and drought protections, including warning, damage control and rehabilitation efficiently and equitably with proper utilization of land and other natural resources.

9) Provide sufficient and sustainable financial support for action programs in line with the national policy, including water related research public relation, information collection and technology transfer to public.

The national water policy will be a framework for implementation of water resources management at national level and river basin as well.

Legal Instrument

The constitution

The Enactment of a Constitution in Thailand in 1997 have a influence on the government's natural resources and environmental policies, the implementation and operation of government projects and the interpretation of relevant laws and regulations. The Constitution provides for:

1) Encouraging local level to participate in preserving, conserving and utilizing natural resources in a sustainable manner such as Section 79 which implied that the Government must strongly support the community participation and Section 88 which states that the participatory and involvement principles will be used as a guideline for the development and enactment of laws and regulations.

2) Decentralizing to the local administrative level to manage and develop the natural resources. Section 290 states that local administrations have rights, functions and powers by laws in managing, conserving, and utilizing the natural resources and environment within their jurisdictions which could affect their constituents. Of course, considering the new projects or activities outside their areas, which could adversely affect the environment and livelihood within their jurisdictions.

3) Encouraging local level in planning, managing and utilizing natural resources and in developing and enacting laws. For example, Section 56 provide scope for communities to work with the local government on natural resources issues and for environment impact assessment to be carried out by independent, but for the provisions to be enacted requires the passing of appropriate parliamentary acts.

4) Data and information for local level to access. For instance, Section 58 states that a person may obtain public data and information from government agencies, state enterprises and local administrations, however, it depends upon what kind of

information can disclosed and how it will be provided. In addition, Section 59 states that a member of the community has right to obtain information, answers and reasons for the issuing permits or undertaking projects or activities which could adversely affect their communities.

The new Constitution not only provides the participatory management, but also obligation on government administrations to implement this approach

Existing Water Laws

There are at least 28 water-related laws, administered by over 30 departments overseeing water issues in 8 ministries

- Table 13 Classification of Legislative Enactment Relating to Water in Thailand

Water Quantity	Water Quality
Canal Maintenance Act, 1903	Canal Maintenance Act, 1903
Water Hyacinth Elimination Act, 1913	Water Hyacinth Elimination Act, 1913
Private Irrigation Act, 1939	Navigation in Thai Waters Act, 1913
Royal Irrigation Act, 1942	Royal Irrigation Act, 1942
Dike and Ditches Act, 1962	Fishery Act, 1947
Minerals Act, 1967	Minerals Act, 1967
Metropolitan Waterworks Authority Act, 1967	Revolutionary Council Announcement No.286,1972
Electricity Generating Authority of Thailand Act, 1968	Groundwater Act, 1977
Groundwater Act, 1977	Provincial Waterworks Authority Act, 1979
Provincial Waterworks Authority Act, 1979	Building Control Act, 1979
Waterworks Canal Maintenance Act, 1983	Factory Act, 1992
Civil and Commercial Code	Public Health Act, 1922
	City Cleanliness and Tidiness Act, 1992
	The Enhancement and Conservation of National Environmental Quality Act, 1992
	Penal Code

According to the mass of Regulatory Control of Water Resources, 2 majors concerned have divided the water laws below;

Surface water

The Civil and Commercial Code

1) Section 1304 states that the water in watercourses is freely accessible and the government is not able to prohibit any private user from withdrawing water from watercourses.

2) Section 1339 allows the landowner to utilize surface runoff water that flows naturally from the higher land, to meet the basic needs (farming, livelihood, and so on.).

3) Section 1355 restricts on a riparian landowner that cannot withdraw water over the reasonable need in order to prevent water shortage in a downstream.

4) The utilization of surface runpff water is regulated by Section 1339 of the Civil and Commercial Code. This section recognises a natural principle that water always flows to a lower place and that a landowner must accept the natural flow of water across the

land. The provision also entitles a landowner to retain surface runoff to meet the need of farm production and livelihood needs and the surplus water must be allowed to flow naturally. The Code also recognises the right of the landholder to retain water in a well or pond and to prohibit access of other persons to this water source.

Irrigation water

There are many provisions that enact in the irrigation projects, which can be divided into 2 major regulations:

1) Private Irrigation Act, 1939

The enactment of the Private Irrigation Act is to regulate water use for agriculture in the private user's irrigation projects. It divided into 3 categories;

- Personal Irrigation

  Section 4 is an irrigation scheme undertaken by a person(s) for the benefit of his cultivation only this kind of irrigation is regulated by the government through a permission process as a person initiating an irrigation project according to Section 7 have to apply for permission from the government authorities

  a) The District Committee if a proposed irrigated area is not larger than 500 rai.

  b) The Provincial Committee if a proposed area is not larger than 1000 rai.

  c) The Minister of Agriculture and Cooperatives if a proposed area is larger than 1,000 rai.

  In addition, the operation of personal irrigation is subject to Section 9 states that if an irrigation project, according to the Provincial Committee, has exceeded its need, the Committee may on occasions issue and order to ration the water to neighboring land. And Section 10 was issued to ensure that the operation of personal irrigation project would not cause damage to other persons.

- People Irrigation

  People Irrigation is irrigation project jointly under by people for cultivation within theirs locality. They would have to obtain the permission according to Section 12 from the authority concerned and its operation and maintenance are under the supervision of the government. The chief of irrigation project in district, sub-district and village level has authorized to plays a role in maintaining and operating an irrigation project, according to Section 21 would be carried out by a chief who would allocate water in proportion with size of land actually cultivated by each water user. If there is a conflict occur from water allocation, they may decide the matter with majority vote and the decision according to Section 27 is final.

- Commercial Irrigation

  Commercial Irrigation is an irrigation project undertaken by a person(s) who collects fee from those using water from the project. A person desiring of operating a Commercial Irrigation project according to Section 30 would have to apply for concession from the Minister of Agriculture and Cooperatives unless the project is temporary in its nature with no permanent construction and obstruction to public waterways, and it does not cause damage to other persons.

Once the concession is awarded, the concessionaire according to Section 32 is authorized to collect fee only from those received water from the proposed project, not from those who have already received water before the existence of the proposed project unless a special new agreement on this matter is reached. In operating the project, the concessionaire according to Section 33 shall not cause damage to other persons and according to Section 34 would have to comply with conditions in the concession. He according to Section 35 is also required to prepare an annual report on the performance of the project and submit it to an official controlling irrigation projects unless it is otherwise stated in writing by such an official.

19) The Royal Irrigation Act, 1942

The utilization of water in irrigation canals is controlled by the Royal Irrigation Act, 1942, which is intended to govern the construction, operation and maintenance of irrigation projects undertaken by RID. The RID has an authority to regulate water utilization and development in order to: (i) keep water in or release water from Irrigation Canals; (ii) dredge, maintain or modify Irrigation Canals, or install any structure in the Canals, and (iii) prohibit or restrict navigation in Irrigation Canals including setting up any condition on the navigation. In addition, Section 32 confirm the presumption that the management of water in Irrigation Canals is legally under control of RID, thus this provision does not allow persons to withdraw water from Irrigation Canals, except for the authorized RID official. Moreover, Section 35 does not give any permission to small water users to use water in Irrigation Canal, however, RID officials would intervene such use when the water become shortage. In addition to water management and allocation, Section 20 states that when an official conveys, drains or pump water to particular plot of land for agriculture, no one shall obstruct the water from reaching neighboring land or a target area. Moreover, the owner or possessor of the land must take a necessary stop to prevent the unnecessary leakage of water from his land as Section 21. To ensure that the owners or possessors of land would comply with Section 20 and Section 21, Section 22 states that the owners or possessors of land not complying with Section 20 and 21 would be liable for wages at a local rate for those employed by the official concerned o do what to be done by such landowners or land possessors. To prevention of excessive use of water, Section 8 of the Act addresses the issue of irrigation fees. The rate of irrigation fee collected from the agricultural users will not over 5 baht per rai per year, for industrial, municipal and other uses will not exceed 50 stangs per cubic meter. Eventually, there are some provisions giving protection to the Irrigation Canals, for example, Section 23 prohibits the construction or installation of any structure or cultivation of corps encroaching Irrigation Canals.

Groundwater

Groundwater is regulated b the Groundwater Act, 1977, which equips the government through the Department of Mineral Resources. For instance, an important control mechanism according to Section 16 requires the permission of drilling, utilizing or recharging groundwater.

Water Quality

There is several Acts concerned water quality. These Acts generally prohibit the dumping o rubbish and other materials, toxic water, and chemicals into the waterways and establish fines and imprisonment for offenders. Most of these Acts are out-of-date and the scope, the fines and punishment and nature of pollution cover are no longer in keeping with modem conditions and circumstances.

River Basin Organization

Establishment of River Basin Organization

There are many government agencies and private parties involved in the development and exploitation of the Basin's surface and groundwater resources, but cooperation and coordination between them is weak. Even when cooperation between operating agencies leads to plans for equitable allocate water, they are often challenged by the various interested parties affected. The result is often a compromise that postpones the problem to a later date. In view of the lack of coordination, the government decided to establish a central agency in water resources management in order to formulate plans, coordinate plan implementation and carry out other works concerning management of water resources. The Office of the National Water Resources Committee (NWRC) was established in November 1996. Since its establishment, the NWRC has worked to strengthen the mechanism of integrated water resources management in Thailand. A notable step forward was the drafting of a water resources law that was recently submitted to the Cabinet. In order to implement the law, a river basin organization or commission will be established in each of Thailand's river basins. This recognizes the need for decentralization as an important step in water resources management. According to the draft law, each river basin commission will consist of qualified persons drawn from public and private sectors. A commission will set policy on water resources planning, development, operation of facilities, and water allocation, and it will oversee all related activities in the river basin including the resolution of water conflicts between various users.

Chao Phraya Basin Organization

The Chao Phraya Basin with an area of a 160,000 sq. km is the largest of Thailand's 25 river basins. The Chao Phraya provides water for the capital city of Bangkok, other large cities, many of the country's main industries, and for irrigation systems covering 1,635,800 ha. Two large reservoirs, Bhumipol on the Ping River and Sirikit on the Nan River, and some smaller reservoirs store the monsoon flows for use in the dry season. As a result of the high degree of regulation provided by these reservoirs almost 75% of the average annual inflow of 36,600 million cubic meters (mcm) is consumed in the Basin. In the dry season, the policy is to give priority to the minimum flows needed to keep salt water from municipal and industrial water supply intakes in the Lower Chao Phraya. But this is in conflict with the demands of farmers who want to grow a dry-season crop. Within the irrigation systems there are also conflicts since the area available for dry-season cropping far exceeds the water available. Such competition and conflicts between users is found in all the sub-basins of the Chao Phraya. Conflicts in quantity are compounded by conflicts in quality, with downstream users suffering the effects of upstream pollution. The Basin also faces a growing problem in the management of groundwater resources. Almost half of Bangkok's supply comes from groundwater exploitation that is not sustainable, and this problem is spreading to other parts of the Basin. Every year the problems and conflicts in the Chao Phraya Basin multiply and, in recent years, abnormally low levels in the reservoirs have sometimes led to situations that came close to closing down the water intakes to Bangkok.

The 1997 report financed by PHRD, the "Chao Phraya Water Resources Management Strategy," found that the establishment of a Chao Phraya Basin Organization is essential to the effective management of the Basin's water resources. The establishment of such and organization would provide valuable experience for setting up similar organizations in other river basins.

Pilot Case Study of River Basin Committee

The study of establishment of Chao Phraya basin organization should be performed as a pilot case study so that when the water law is enforced, the river basin commission will be immediately set up according to the result of the study.

To study the establishment and operation of Chao Phraya basin organization or commission which will be set up in the future when the water law is enforced, such the commission must compose of appropriate function and composition. Rules and regulations to support its work must be delineated. The study also includes clear determination of its roles and relations to other agencies and its staff office to support its administrative work. This study will also be considered as a case study for establishment of the commissions in other river basins.

In 1999, ONWRC has been working with major water-related agencies, water users, NGOs, farmers' cooperatives, academics, and local governments to establish three River Basin Committees (RBCs) of Upper Ping, Lower Ping, and Pasak. There is a great concern of ONWRC to keep the initial models and methods quite flexible to allow some appropriate adjustment during the pilot operation. ONWRC also appointed the RBC-support teams to provide managerial and technical support to the establishment.

Establishing Process and ONWRC support for RBCs

ONWRC works to increase community and stakeholder participation and representation in RBCs and key activities of unified water resource management and decision-making. ONWRC's RBC Teams are responsible to provide managerial and technical support to RBCs. The members of the team come from different divisions, and are coordinated by mid-level personnel from the Operation Division. The teams have to be responsible for all inter-agency and inter-level communication. Also, the coordinators take a double appointment to be assistant secretary or a member of Secretariat to the RBCs. This overlapping structure assists to facilitate communication and also increase close partnership of ONWRC and RBCs at regional level of the river basins.

River Basin Committee Structure and Composition

The organization structure is based on administrative area representation (district and sub-district) and sub-watershed. It was a great concern on the proportion of membership, selection process, representation, qualification, and appointment. ONWRC has provided supports in increase the representation of NGOs and local academic/ research institutions as well as the selection procedures. With limited time frame, the first round of selection and appointment were mainly depended on the advice of the district office. Then, the initial appointment is required from official regulations to have legal status of RBC before any activities can be organized to use the budget, personnel support, and other resources. Then, this is considered as an interim RBCs which can be flexible to allow some future adjustment in term of scale and composition to increase appropriate representation and accountability. There are some interest and cooperation from local NGOs and academics to take part in the RBCs and activities.

ONWRC has initiated RBC structure with a combination of both agencies' members and the private stakeholders from all sectors including NGOs and academics. In the Upper Ping, there are two to three members from NGOs and academics joining SRBCs, and three of them in RBC structure. Generally, it was designed that membership of government agencies and local stakeholders / water users would be a ratio of 1 person: 1 person or 50 percent of each group. In practice, the RBC may have a larger percentage of the non-agency group. While the accountability of membership and selection process require further improvement, the representation is reasonably appropriate at this initial stage of RBC establishment.

River Basin Committee Responsibilities

Initially, RBCs have been designed to have three major responsibilities including addressing priorities in water resource issues, to promote public education and sustainable water resource management, and to facilitate local public consultations with stakeholders and beneficiaries.

RBC's responsibilities are explained as possible responsibilities in relation to the SRBCs/ Regional Committee, Working Groups, and Secretariat Office. There are six major possible responsibilities of RBC. In addition a new possible responsibility for RBC which should deal with the conflict resolutions and the problem solving between the sub-river basins and between the related local and regional agencies. The proposed selection process could retain the representative of the sub-river basins in the planning process and to strengthen their representation at RBC level. The working groups should work to prepare the draft action work plan, which would be reviewed by SRBCs / and approved by RBC.

RBC should further expand their key responsibilities to include conflict resolutions, an abstraction license, and revenue collection. These will enable RBCs to grow stronger, and also to develop to be a decentralized decision making body which are semi-independent from ONWRC and RID in the future. RBCs, therefore, have to improve their capacity to carry out their own financial management.

Bang Pakong River Basin Committee

Rational and objective

The development of Eastern Sea Board effected the growth of infrastructure and water needs. Apparently, the problems of water-related activities have increased and need to be solved immediately such as the management of river basin level and project level problem. From these circumstances, the Cabinet submitted on the development of the economic zone in Eastern Sea Board to study on making a scheme of development and management of water resources in eastern region, especially in 3 Provinces (Chachengsao, Chonburi and Rayong Provinces) and surrounding provinces. The Office of the National Water Resources Committee had been appointed to cooperate with the Royal Irrigation Department and concerned agencies. The framework focused on the river basin institution, the development of information system, and the water laws and regulations in order to meet the most effective in the water resources management.

The Establishment of Bang Pakong River Basin Committee

The stakeholders' meeting in Bang Pakong River Basin held several time in order to receive the information, problems, advice and so on from government agencies, state enterprises, water users, local administrative, NGOs, and educated institutions in Bang Pakong River Basin who will determine the structure, composition, and power and responsibility of the Bang Pakong River Basin Committee.

Deputy Prime Minister, Chairman of the National Water Resources Committee issued the Order of the Establishment of Bang Pakong River Basin Committee on July 26, 2001. The composition of the membership of the Bang Pakong River Basin Committee is listed in Annex 11.

Responsibilities

The responsibilities of the committee are as listed below

1) To operate water resources management in the Bang Prakong-Prachinburi Basin area that covers Prachinburi, Chachoengsao, Nakhon Nayok and Sakaeo Provinces.

20) To give opinion and advice to the National Water Resources Committee on policy making, project planning, arid problem solving on development, conservation, and use of water resources, together with other activities relating to water resources management and the operation of other involved agencies in the specified river basin.

21) To give advice to the responsible agencies on project planning, problem solving, and any activities relating to water resource in the specified river basin.

22) To coordinate the formulation of action plans of government agencies in the basin involving the development and conservation of water resources, water allocation, rehabilitation of watershed area, and prevention and resolution of water scarcity, flood, and water quality problems in the specified river basin in order to formulate the comprehensive action plan for the river basin.

23) To determine the volume of water use, water allocation and other measures that ensure appropriateness, fairness, and efficiency of water allocation.

24) To monitor and evaluate the operation of the agencies involved in water resources in the specified river basin.

25) To request information and facts of water resources from the concerned agencies so as to collect statistics, data, information, opinion, and suggestions on water resources management, development, conservation and problem solving of water resources as well as protection and resolution of flood, water scarcity, arid water quality problems in the specifies river basin.

26) To reconcile the conflicts of water resources management that occur in the specified river basin.

27) To coordinate the operation of water resources management with the Committee of the other related river basins.

28) To disseminate information, inform people and hear their opinion as well as create public understanding about the operation and the results of the Committee.

29) To establish working groups to do any task assigned by the Committee.

30) To undertake any task assigned by the National Water Resources Committee.

Major Stakeholders in Bang Pakong River Basin

Considering allocation of good quality of water to various groups of users in the basin, stakeholders who are involved can be grouped into 3 categories: decision maker, implementing agencies, and water users. These categories have been identified as follows:

1) Decision maker and also regulator/standard setter

The Bang pakong River Basin Committee should represent this group of stakeholder. Its composition comprises representatives of the rest in the categories.

31) Implementing agencies or resources manager and also operator/service provider

According to its function this category can be divided into:

- Group 1 concerns mainly with provision and allocation of surface water, they are
  - Royal Irrigation Department
  - East Water Resources Development and Management Public Company Ltd.
- Group 2 concerns mainly with controlling of groundwater use:
  - Department of Mineral Resources
- Group 3 concerns mainly wiyh water quality, they are
  - Department of Pollution Control
  - Department of Public Health
- Group 4 other bodies/ authorities (local administrative body):
  - Municipality
  - Tambon Administrative Organisation (TAO)

32) Water users

Large groups of water users are

- Household which is represented by Provincial Waterworks Authority, municipality
- Agriculture which is represented by water users'organisation
- Industry which is represented by Industrial Estate Authority

All these sectors have their own reponsibilities and roles that will be followingly explained.

1) Bang Pakong River Basin Committee

While ultimate goal of its establishment includes many perspectives and bulk allocation of water is also one of its functions, but condidering its recent establishment the Sub-committee does not obtain considerable capacity to perform the work at present. Therefore, implementing agency like Royal Irrigation Department is the key actor in allocating water both for large and small group of users.

33) Royal Irrigation Department (RID)

RID operates work to supply and allocate water for agriculture, public utility and industry and work on water-related disaster prevention, safty of dam and water transportation in irrigated areas. Its role includes providing and managing water use in irrigated areas which constitute for 23 per cent of agricultural area of the country.

34) East Water Resources Development and Management Public Company Ltd.

East Water's core business is managing water resources especially raw water transmission systems for industrial and consumer use. Originally its business concentrated only in East Coast Basin but now expands to Bang Pakong Basin.

35) Department of Mineral Resources (DMR)

DMR operates according to the law on Groundwater, studies, analyses and resrarches on groundwater, at present planning for groundwater and surface water are entirely seperated. Only in Bangkok and its precinct that conjunctive use for consumption is being considered.

36) Department of Pollution Control (DPC)

DPC recommends formulation on policy and plan on water quality, formulates environmental quality management plan on water, monitors and examines water resources quality and sources of wastewater in the basin.

37) The Department of Energy Development and Promotion (DEDP)

DEDP is in charge of the overall energy development policy, carries out the water resources development works and implements medium-small scale pumpimg projects for irrigation in order to secure adequate irrigation water, however, it depends upon the water availability.

38) Provincial Waterwork Authority (PWA)

PWA is resposible for production and distribution of potable water e.g. domestic, industrial, etc., which includes source development, conveyance, pumping, treatment, storage, and distribution facilities.

39) Tambon Administrative Organization (TAO)

TAO operates maintenance of watercourse and manages water resources especially in its administrative boundary, formulates plan, and prepares budget for plan implementation. TAOs are new entitles with limited technical and managerial capacity and no experience in water management. Capacity building in simple technical knowledge in water resources is needed for nearly every TAO.

40) Water Users' Organization (WUO)

Water Users'organization, in general, is divided into two main groups ie., formal or legal and informal or customary. A formal organization is organized by law for formal arrangements among the water users with specific purposes being deciced by them. The organization then becomes a form of legal body.

At present, there are two types of water users' organization, ie. WUA and WUC that are classified as the formal group. An informal institution is organized by informal arrangements amoung the water users that incorporate traditional, religious, social values, or performing certain purposes. There are currently 4 water users'organizations are classified as the informal group, ie. Traditional Irrigation Association, People Irrigation Association, Water Users'Group and Water Administration Group

Water Mangement

Irrigation Scheme

Water management in the Bang Pakong river basin is conducted at several levels. At the upper one, the level of the whole basin, water resource is managed by several administrations but mostly by the RID

Deliveries in the dry season are calculated according to basic requirements (transportation, urban requirements and salt-water control) and the share for agriculture depends on the available amount of water stored in the dam. In the rainy season, at least during the August-November period, management mostly aims at dividing exess flows in the different waterways in order to control the flood and avoid damages.

In both cases, this is achieved mostly through experience and manual regulation when the situation borders excessive imbalance. The situation is monitored by the Office of Regional Irrigation 9 located in Cholburi Province and by the Central Office in Bangkok.

At the Project level, monitoring and regulation mostly concern the truck or primary canals, whereas at the secondary level, water management is under the control of zonemen who take care of an average of 2,000 ha. At ditch level, at last, farmers manage water by themselves. This division works until some breakdown appears in the network: water shortage or exess of water observed at a given level will be reported to the level above, who will endeavour to balance thesituation. If the problem has its origin at an upper level, then the information will proceed upward.

Observations of water levels and discharge at the main regulation structures are recorded five times a day by the zonemen who transmit them to the Project's Office. Specific data related to water control in the main waterways is further forwarded to the regional office and Bangkok main office. At the project level, however, this large amount data is seldom analysed and regulation is mostly based on experience, with responsiveness limited to the abnormal situations observed and reported by the lower levels

Allocation to main canals regulated by RID. Secondary tirtiary canals and on-farm levels are managed by WUO. There is no water charge but farmers may pay for the system maintenance to WUO.

Waterworks Schemes

1) Eastwater Scheme

Main pipeline for raw water delivery is constructed in Cha Cheong Sao and Chonburi Provinces in order to distribute water to PWA, Industrial Estate Authority and factories. It is planned to meet demand of all these purposes up to the year 2007.

41) PWA Scheme

Only some restricted areas have been serviced by PWA. It has caused lack of enough clean water for people and the service has been supplement by village waterworks.

42) Village Waterworks Schemes

They are managed by TAOs and other agencies and their budget derived from local tax and money allocate by central government. Within the year 2006 all village waterworks will be transferred to TAO. Their management will be done jointly with WUO.

SWOT Analysis and Discussion

The Establishment of Bang Pakong River Basin Committee

The establishment of River Basin Committee is a mechanism of decentralization of water resources management to representatives of stakeholders in a river basin area, aiming to stimulate people participatory in decision making and problem solving which will lead to effectiveness, equity, and sustainability.

Bang Pakong River Basin Committee established in 2001. Obviously, it is in the initial stage and mostly concerned with selection of the representatives from stakeholders. In addition, it must set up the organizational network to link with grassroot organizations. The process must be designed in parallel with capacity-building at all levels. This can be shown as follows:

1) River basin level

In order to manage water resources at this level, the work includes establishing a river basin committee, creating its network, and strengthening the organization by using various tools which are planning and designing for budgetary process, monitoring, collecting basin data and information such as surface water, groundwater, demand for water, agricultural plan, water quality, risk area, water user groups, etc. Moreover, a research and study and interactive communication with public are also needed.

43) National level

The key role is to provide the management model and mechanism for river basin organization. To give some examples they are formulated integrated water resources management plans by a participatory approach, improved the process of budget allocation in order to reduce the overlapping projects and to be in accordance with national water policy. Furthermore, research and study to formulate management model for river basin organization involving the development and conservation of water resources, water allocation, preservation water resource, prevention and resolution of flood, water quality problem, and so on is important.

44) International level

The establishment of network of water resources management is considering worldwide and International Network on Basin Organization (INBO) has been established. Basically, respective country has its own specific character and its frameworks for management are different. Cooperation among themselves in term of technology and experiences transfer will be an important factor for an achievement in this area.

Working Process of Bang Pakong River Basin Committee

Since its establishment in 2001, its initial work was a selection of genuine representatives from private sector. The selection process was carefully designed in order that representatives from every group of stakeholders were genuinely represented. When its composition was completed, the Committee set up working groups and assigned them to do three tasks which are formulation of river basin plans, collecting river basin information and coordination for public relation. However, previous experiences showed that all these tasks were properly derived by working within administrative boundaries. It meant working groups had to be established at each level of administrative bodies and the work then prepared at the smallest units which are tambons and provinces. Therefore, the Bang Pakong River Basin Committee set up three levels of working groups namely working group at the province level, working group at the tambon level and working group at the village level. To stimulate and strengthen them, ONWRC plans to formulate integrated plan for the river basin. It will emphasize capacity building component by practicing the River Basin Committee and the Working Groups with planning process and giving them relevent knowledge.

SWOT Analysis of Institution in Bang Pakong River Basin

1) Strength

- Having a River Basin Committee (RBC) that is flexible in its composition,
- Having an Office of the Prime Minister's Regulation on Water Resources Development and Management to be a legal basis for the RBC,
- Having representatives from various groups at different levels to participate in the working group established to help functioning RBC,
- Will have an integrated planning step introduced to the RBC and other stakeholders.

45) Weakness

- Having many agencies concerned in water resources management in the river basin,
- Lack of an information system of the river basin,
- Lack of well defined direction and goal for the RBC,
- Lack of continuity of technical arms in the RBC Secretariat,
- Lack of general acceptance in process of selection of RBC's member,
- Lack of full range of organizations that link to the small areas of the river basin.

46) Opportunity

- Having support from core agencies at national level e.g. NESDB, Budget Bureau and Civil Services Commision,
- Will have experienced and capable staff from other agencies transferred to new Development of Water Resources which will establish in October 2002 according to public sector reform,
- Do not encounter with resistance from NGOs.

47) Threat

- Selection of RBC's members does not represent genuine representatives,
- Lack of active participation from stakeholders,
- Lack of cooperation from concerned agencies,
- Problem occurred with Bang Pakong Dam will have a negative effect on RBC.

Discussion Following SWOT Analysis

At this stage the works have been concentrated on a selection of genuine representatives from stakeholders and then strengthening the River Basin Committee. They are fully dynamic considering both the selection process and the capacity building components. Eventually, the target of solving water-related problems in the river basin will be scrutinized and proposed by the River Basin Committee. At some certain stage, the River Basin

Committee will possess with full capacity in considering various aspects and making decision. However, capable implementing agencies are basic requirement for any success.

Diversified use of water in Bang Pakong is a crucial factor for working direction of the basin. Major water uses in industrial sector and communities make it different from other basins. Emphasis must be placed to waste water treatment and in this connection, the role of various local agencies should be enlarged and strengthened. The River Basin Committee should link its work to the local agencies' work. Developing of river basin's plan and information should take into account all these factors.

After a new Department of Water Resources is established, a river basin management should be trained among staff of this Department. Socio-economic implication of the river basin management should be focused as well as technical aspect, in order to ensure a success.

Conclusion

The pilot case study and the establishment of the Bang Pakong River Basin Committee reflect two critical points. First, a selection process of its representatives from various groups of stakeholders should be designed in a very careful manner in order that the representatives selected are genuine and well-represented. Second, a system of linkage to agencies at different administrative boundaries including local units should be established in order that the work of the River Basin Committee will be formulated from the smallest unit of administration. It will create a unity in water management work.

Good exercise for the Bang Pakong River Basin Committee is learning and establishing a process of problems solving. This will include capacity building for the River Basin Committee to effectively plan and furnish themselves with a capacity to consider budgets and monitor implementation. It is important to strengthen all other involved parties, which are staff of the new Department of Water Resources, staff of local administrative bodies and water uses groups. This component should be furthered studied and practiced.

Chapter

5

Synthesis and Recommendations

This report provides a synthesis of three distinct analyses conducted for the "Development of Effective Water Management Institutions" in Thailand. Two river basins were examined for the study: the Mae Klong River Basin and the Bang Pakong River Basin. This reports documents the major findings for the Bang Pakong River Basin; while, a separate report exists for the Mae Klong River Basin.

The three analyses done for the study include water accounting analysis, a socio-economic analysis, and an institutional analysis. Research was conducted from a river basin perspective, as it has become widely accepted that the river basin scale is the appropriate scale from which to manage water resources. The goal of this study was to identify linkages between these three components so as to better identify and design effective water management institutions.

Report Summaries

This section offers a brief review and "lessons learned" summary from each of the three research components. Specific details for each of the components can be referred to in the separate reports that were written for each of the components. Descriptions of the linkages were developed from research findings, internal brainstorming sessions, and discussions with key experts.

Water Accounting

Water accounting is a framework for describing the use and productivity of water within a given area. The methodology for water accounting is based on the use of water balances. It considers the inflows and outflows for different water use boundaries such as basins, sub-basins, and smaller divisions. For this study, the Bang Pakong River Basin was divided into seven different sections. These sections were based on the existence and location of gauging equipment that would facilitate the study, as data was readily available. See Annex 2 for a map of the seven different sections. The seven sections were also used for the Socio-Economic Analysis to facilitate comparisons and identification of linkages between the different research components.

Water accounting calculations were done for each section on a seasonal and annual basis. The importance of storage and inter-basin transfers of water into the basin are shown by the high depleted fraction during the dry season. This high fraction of depleted water use is evident on an annual basis as well.

Analysis of data showed that gross inflow in wet season is larger than depleted water, but in dry seaso is less than depleted water. The ratio of depleated water to gross inflow is decrease from upstream to downstream basins. The ratio of depleted water to available water is higher than 90%, it means most available water in domains was depleted. This includes evaporation in waterways, evaporatranspiraton in fallow lands, water which flows to the sea, and other location where it is not economically recovered for reuse, water which unfit for certain uses, and water which incorporation in to a product. From available water, there are 70% of available water was use in process consumption or depleted to produce a human intended product such as crop evapotranspiration and comnsumption from domestic and industrial use, and 80% of depleted water was use in process depletion. From this analysis, the basin efficiency of basin is about 90%, it showed that this basin has high effective water consumption.

From the water accounting analysis, development for this basin should do in management section such as modifying crop schedule, crop pattern, improve water quality, decreasing non intended use, or other product increasing method because there is little potential and not economically to construc any infrastructure in this basin.

Socio-Economic Analysis

The Socio-Economic Analysis was conducted to document the general socio-economic description of the Bang Pakong River Basin. Additional analysis was conducted to assess the performance of irrigation within the system. Data sets were gathered and aggregated according to the areas devised for the water accounting activities (as shown in Annex 6). This section offers a brief summary of the basin and irrigation performance. Special attention is paid to the poverty situation in the basin and impacts that can have on the effective management of river basins.

Analysis of the data showed that rural poverty is most concentrated in the two areas of Khlong Phra Sathung and Khlong Phra Prong.[6] However, there does not appear to be any clear relationship between the poverty rate and the percentage of farms irrigated. The rural poverty rate ranges from 48% in the Khlong Luang Area up to 85% in Mae Nam Hanuman (using the official Thai Poverty Line). The gender structure of rural poverty remains roughly constant averaging about 50%. Of particular interest is the relatively low number of poor working in agriculture, which averages 21.6%. This is drastically lower than the 63% recorded in the Mae Klong River Basin. Other factors which need to be considered in relation to poverty within agriculture include distance to market, degree of local markets, and suitability of land for farming.

Influence in the policy making process among all water users is shown to be lowest for farmers and even lower for poorer, non-irrigating farmers. However, water is still the largest bulk user of water. It will be necessary to address this traditional imbalance between influence on policymaking and irrigation water use. As water scarcities increase, the potential exists that the more influential users will gain a larger share of the water at the less influential users' expense. This could exacerbate the poverty problem within the basin.

Income per rai for paddy crops appears stable across the basin, except in Khlong Luang where income for paddy is trending upward. This mirrors an increase in yields for paddy in the Khlong Luang Area. Yields seem somewhat lower in the upstream portions of the basin; however, a definite conclusion will require more data. The upstream sections tend to have more land area in production of maize and cassava but paddy remains the key crop.

[6] Data is currently being cleaned, so some anomalies are expected. Results are to be treated as indicative only.

From the Socio-Economic Analysis, a number of conflicts were identified that currently exist between various water users within the basin. A table listing these conflicts is presented in Annex 9. The table illustrates the conflicts and tradeoffs arising from a number of stakeholders. The dominant characteristic of the tradeoffs is that they primarily involve irrigators versus another group or conflicts among different groups of irrigators. Since irrigators were also shown to be the least influential in the decision-making process, they will likely be the loser in any conflicts especially since effective conflict resolution mechanisms remain weak or undeveloped. Within irrigator groups, a poorer irrigator is likely to suffer a similar outcome.

Finally, an analysis of irrigation performance was conducted for the irrigation systems in the Bang Pakong River Basin. The most striking feature of this analysis is the zero ranking for the financial self-sufficiency criteria. This is a direct result of irrigation being provided as a free public good. This creates a situation were the management of the irrigations systems is fully dependent on funding from the government in order to operate. By not being financially independent, an irrigation system remains dependent on the government and more susceptible water management decisions that are not in the system's best interests. Another feature is that relative water supply indicator is over 1, while the relative irrigation supply is negative. This is a result of rainfall exceeding crop water demands, usually by a great amount. This does not, however, illustrate seasonal scarcities that may exist. Increased water storage could be a necessary development if seasonal water scarcities become more acute.

Institutional Analysis

The Institutional Analysis was conducted to identify the institutional structure of water resource management as it applies to the Bang Pakong River Basin. The most obvious finding of the Institutional Analysis is the strong national focus of the analysis. There appears to be little actual development of local and basin level institutions for the management of water resources. This stems in part from the lack of a comprehensive water resources law at the national level. There also are a large number of diverse government agencies that carry some responsibility for management of water resources. In October 2002, a major reorganization of the government will take place. Of relevance here, is that the department of Water Resources will be removed from the Ministry of Agriculture and place in the Ministry of Natural Resources and Environment.

While the general concepts of effective water management have been recognized (e.g. river basin management, farmer organizations) and initial steps have been taken to implement these concepts, the existing structure is still lacking in its ability to effectively realize these management concepts. The guiding principles followed by the government for managing river basins are given as efficiency in problem solving, equity in allocation, and participatory management processes. Current institutional arrangements are felt appropriate to achieve these ideals by members of the ONWRC.

Thailand has created by a decree from the Prime Minister a national apex body for the management of water resources. This body is known as the Office of the National Water Resources Committee ONWRC. This office is responsible for coordinating and formulating policies and regulations as well as overseeing the river basin organizations. The river basin organizations have been organized to decentralize the management and development of the water resources. In 2001, the Bang Pakong River Basin Committee (BPRBC) was established by the ONWRC. The BPRBC will have responsibility for management coordination and water resource regulation for the Bang Pakong River. The Institutional Analysis report cites the difficulties facing the newly formed River Basin Committees in fulfilling their tasks. A significant problem is that there is general lack of agreement in the selection of the committees members. Furthermore, the current membership list is felt to inadequately represent the stakeholders.

While many of the needed developments and reforms are embodied in the National Water Vision, there remains a large gap in setting up in concrete terms the necessary framework. The Draft Water Law, for example, calls for the establishment of the river basin committees and provides for a process of dispute resolution. However, the draft law does not grant either the river basin committee or the dispute resolution agencies any real authority to rule on disputes.

Existing laws related to the management of water resources are often old and based on conditions that no longer exist. For instance, Section 1304 of the Civil and Commercial Code states that water in water courses is freely available and that the government cannot prohibit anyone from withdrawing this water. The Code does place limits on withdrawals based on limits of reasonable need upon users. The Royal Irrigation Act of 1942 addresses canal irrigation. The Royal Irrigation Act sets a limit for irrigation fees at 5 Baht per rai per year. Besides being extremely low, this fee is currently not collected in the basin. This creates a problem where the irrigation management is entirely dependent on receiving subsidies from the government in order to stay financially feasible.

While many reforms have been made regarding changes in the administrative structure, there remain deficiencies in the management capacity of newly formed organizations such as the RBC, Tabon Administrative Organizations, etc. These organizations will need to receive substantial capacity building efforts to build the experience and know-how required to effectively manage the water resources under their control. This point seems especially relevant to the newly established RBC.

The Bang Pakong Diversion Dam is operated by the Royal Irrigation Department. There are several conflicts surrounding its operation. The two most serious conflicts include balancing the divergent needs of water users below the dam and water users above the dam. The second conflict is between the water storage needs of the diversion dam and the environment. Original plans called for the construction of 12 storage reservoirs upstream. Environmental concerns are currently preventing the construction of these dams. This hampers the full effectiveness of the diversion dam. The recently established river basin committee will face a big challenge in resolving this issue.

Recommendations and Conclusions

The previous sections have briefly reviewed and highlighted findings from the three analyses conducted. The water accounting component indicated the current situation of the basin. Currently, water is still adequate on an annual basis, but this situation may reverse under a number of scenarios come to being in the future. Among these scenarios is increased irrigation by sugarcane growers and increased diversions to Bangkok. Either of these scenarios could create a situation where water quantities are insufficient to meet demand.

The Socio-Economic Analysis and Irrigation Performance Analysis highlighted the important role that irrigators play in water management of the basin. In particular, agriculture plays a significant role in the basin, both in terms of livelihoods and as a factor in poverty alleviation. Farmers in general are not very influential in the policy making and decision making process. They are, however, among the most vulnerable.

The Socio-Economic Analysis also illustrated the declining paddy prices faced by farmers in the river basin. This could create a situation where poverty increases in the upstream and income inequality increases within the basin.