Directorate General of Water Resources
Ministry of Public Works
The Republic of Indonesia

SURVEY FOR MAXIMUM UTILIZATION OF IRRIGATION WATER IN THE REPUPLIC OF INDONESIA

FINAL REPORT

April 2012

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
<contract to>
NIPPON KOEI CO., LTD.

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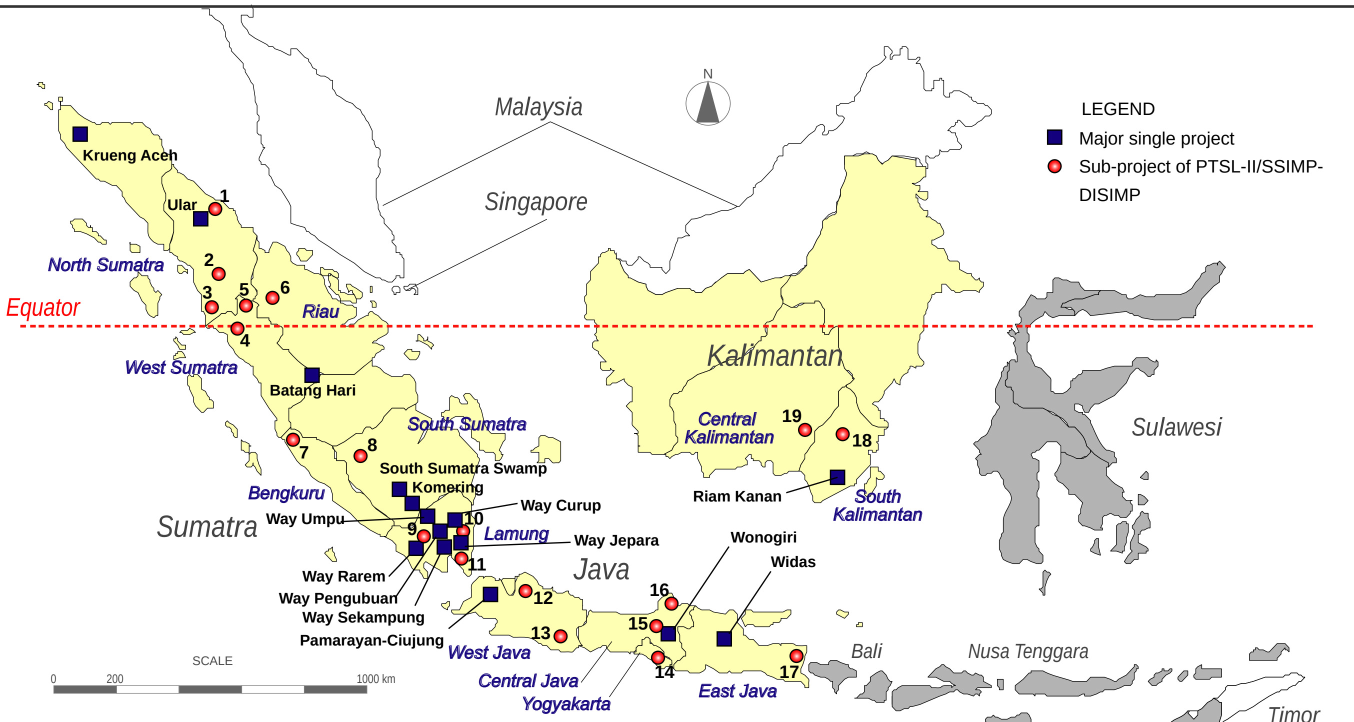


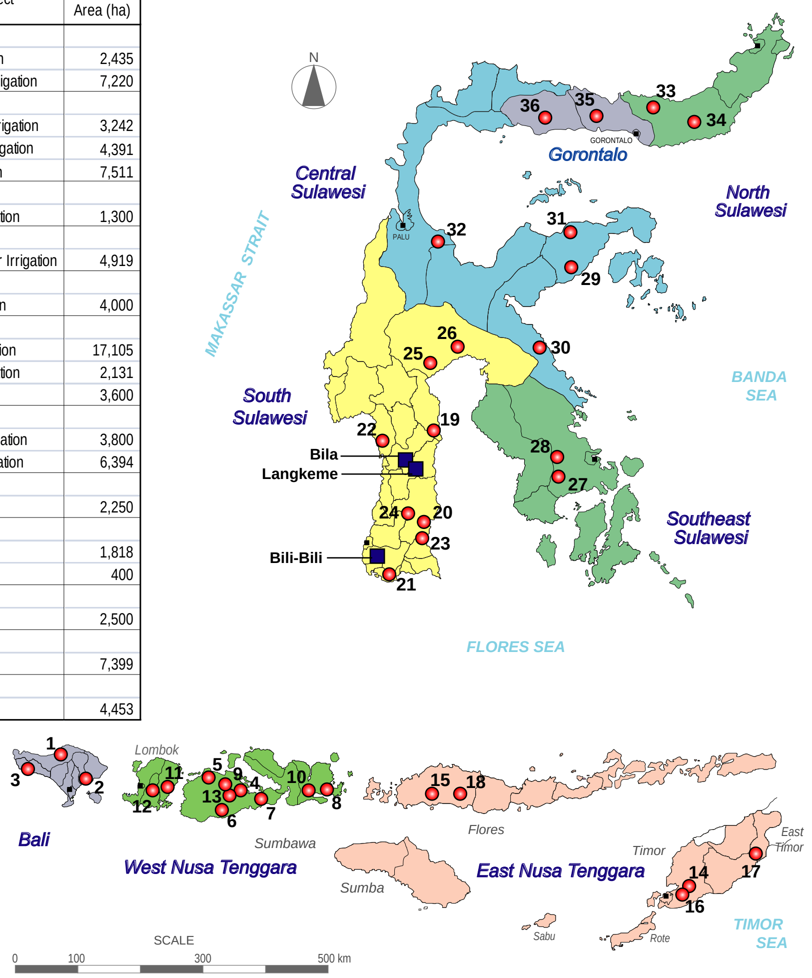
West Indonesi (Java・Sumatra・Kalimantan)

SSIMP-DISIMP (>1,000 ha)Sub-projects

	Province / Sub-project	Irrigation Area (ha)
Bali		
1	Saba River Basin Weir Irrigation	4,050
2	Unda River Basin Weir Irrigation	4,290
3	Bilukpoh-Tukadaya Weir Irrigation	2,110
West Nusa Tenggara (NTB)		
4	Tiu Kulit Dam Irrigaton	1,800
5	Bringin Sila Weir Irrigation	3,100
6	Pelara Weir Irrigation	2,292
7	Gapit Dam Irrigation	1,300
8	Sumi Dam Irrigation	2,542
9	Batu Bulan Dam Irrigation	5,577
10	Pelaparado Dam Irrigation	4,015
11	Ijobalit Weir Irrigation	1,168
12	Jurang Sate Irrigation	3,491
13	Mamak-Kakiang Irrigation	5,314
East Nusa Tenggara (NTT)		
14	Oesao Groundwater Irrigation	1,200
15	Wae Mantar II Weir Irrigation	1,594
16	Tilong Dam Irrigation	1,484
17	Malaka Weir Irrigation	10,000
18	Wae Dingin Weir Irrigation	2,516
South Sulawesi		
19	Awo Weir Irrigation Extension	2,750
20	Salomekko Dam Irrigation	1,722
21	Kelara-Karalloe Weir Irrigation	7,004
22	Sadang Weir Irrigation	58,000
23	Kalamisu Weir Irrigation	2,000
24	Ponre Ponre Dam Irrigation	3,749
25	Lamasi Kiri Weir Irrigation	4,332
26	Kanjiro Weir Irrigation	1,910
Southeast Sulawesi		
27	Benua Apolo Weir Irrigation	3,000
28	Wawotobi Weir Irrigation	8,000
Central Sulawesi		
29	Sinorang Weir Irrigation	3,339
30	Karaopa Weir Irrigation	2,494
31	Bella-Kumpi Weir Irrigation	2,637
32	Sausu Weir Irrigation	7,301
North Sulawesi		
33	Sangkub Weir Irrigation	2,200
34	Kosinggolan Irrigation	4,400
Gorontalo		
35	Paguyaman Weir Irrigation	6,880
36	Gorontalo Weir Irrigation	5,956

PTSL-II Sub-projects

	Province / Sub-project	Irrigation Area (ha)
North Sumatra		
1	Simodong Weir Irrigation	2,435
2	Batang Angkola Weir Irrigation	7,220
West Sumatra		
3	Batang Bathhan Weir Irrigation	3,242
4	Batang Tongar Weir Irrigation	4,391
5	Panti Rao Weir Irrigation	7,511
Riau		
6	Batang Okak Weir Irrigation	1,300
Bengkuru		
7	Muko-Muko Kanan Weir Irrigation	4,919
South Sumatra		
8	Air Lakitan Weir Irrigation	4,000
Lampung		
9	Way Rarem Dam Irrigation	17,105
10	Way Churup Weir Irrigation	2,131
11	Jabung Weir Irrigation	3,600
West Java		
12	Lemah Abang Weir Irrigation	3,800
13	Leuwi Goong Weir Irrigation	6,394
Yogyakarta		
14	Sapon Weir Irrigation	2,250
Central Java		
15	Lanang Weir Irrigation	1,818
16	Lodan Dam Irrigation	400
East Java		
17	Bajulmati Dam Irrigation	2,500
South Kalimantan		
18	Amandit Weir Irrigation	7,399
Central Kalimantan		
19	Karau Weir Irrigation	4,453



East Insdonesia (Sulawesi・Bali・Nusa Tenggara)

Irrigation Project Location Map completed by Japanese ODA

Except on going projects as PIRIMP,DISIMP-II etc.

要　約

調査実施の背景

1. インドネシア政府は、国民の主食であるコメの供給確保と価格安定を重要な政策目標とし、灌漑開発・農業技術普及を通じ、建国以来コメの増産に力を入れてきた。我が国は、インドネシア政府の政策に沿って各地で灌漑システムの開発・改修を支援してきた。これらの灌漑システムは農業用水供給を安定させ、農業生産を向上させるために貢献しており、気候変動への適応策としても位置付けられている。

2. 水資源は灌漑用水として最も多く利用されているが、国内経済の発展とともに都市用水・工業用水・水力発電用水・養殖用水の需要が急速に増え、ジャワ島においてはセクター間の水資源利用競合が生じ、さらに既耕地の農外転用も拡大している。一方、スマトラ地域やカリマンタン地域においては、近年の商品作物の市場価格高騰により、稲作よりもオイルパームやゴムなどの永年作物栽培を志向する農民が増えており、農業セクター内で土地資源利用の競合が生じている。

3. 灌漑セクターにおいては、灌漑施設が整備済みであるものの水田造成が未実施の灌漑地区や、逆に灌漑施設整備の遅れによって天水田が残る灌漑地区が、いずれも多数存在している。特に水田整備が進まない一つの理由としては、法令で農民の責務となっている末端灌漑水路の整備を実施した後の農業経営の見通しが明確でなく、農民がその負担に消極的になっていることがあげられる。このような背景から、灌漑用水を高度に利用した、より付加価値の高い農業経営モデルを農民に提示することが求められている。

調査の目的と実施

4. 本調査では、灌漑システムの水資源を有効に活用し、コメとの組み合わせにより農民にとってさらに魅力のある営農形態となるような水産を含む食料生産、ならびに再生可能エネルギー源としてのバイオマス用途の作物栽培および小水力発電を行う可能性について調査し、インドネシア政府に対して提案を行うことを目的とする。加えて、円借款にて整備した灌漑施設の現況を調査することを目的とする。

5. 本報告書は、2011 年 8 月 26 日にインドネシア政府公共事業省 (MPW) 水資源総 (DGWR) と国際協力機構 (JICA) との間で締結された協議議事録に基づき、2011 年 10 月 24 日から 11 月 27 日まで実施した現地調査と解析結果を取りまとめたものである。なお、本調査結果の取りまとめ期間である 2012 年 1 月に、インドネシア政府関係機関が大統領指示に基づいて共同策定していた「2014 年 1 千万トン備蓄に向けた国家コメ増産指針」が幹事役の農業省 (MOA) から発表され、引き続いて 2 月に国家開発企画庁 (BAPPENAS) によりマクロ経済運営上の重点課題、3 月に MPW により灌漑セクターの最重要政策としてそれぞれ位置付けられたことから、本報告書ではその計画について取り上げることとした。

灌漑セクターの現状

6. 計画灌漑面積は、2007 年時点で全国に合計約 877 万 ha あり、1992 年から約 46 万 ha 増加した。その水源形態別・地域別面積の推移を次表に示す。このうち表流水灌漑面積には、貯水池などの水源施設から年間を通じて灌漑用水が供給可能な地区約 80 万 ha が含まれているが、その面積比率は、スマトラ地域 5.9%、ジャワ地域 18.5%、バリ・ヌサテンガラ地域 6.9%、カ

リマンタン地域 1.4%、スラウェシ地域 3.9%、全国平均で 11.1%にとどまっている。

地　域	表流水灌漑 (千 ha)		潮汐灌漑 (千 ha)		地下水灌漑 (千 ha)		合計 (千 ha)	
	1992	**2007**	**1992**	**2007**	**1992**	**2007**	**1992**	**2007**
スマトラ	1,984	1,999	1,144	692	4	4	3,129	2,695
ジャワ	2,169	3,305	0	0	42	68	2,211	3,373
バリ・ヌサテンガラ	416	434	0	0	79	12	495	446
カリマンタン	188	511	603	280	0	0	791	791
スラウェシ	1,005	867	521	72	26	7	1,552	946
マルク・パプア	75	114	58	409	0	1	133	524
合計	5,837	7,230	2,326	1,453	151	92	8,314	8,775

出典: JICA 報告書（FIDP）and DGWR database

7. 国の地方分権政策方針に則して施行された 2006 年法令第 20 号灌漑法により、すべての灌漑地区の管理主体が、下表に示す規模と行政区界を基準に、中央・州・県政府に仕分けられた。

位　置	計画灌漑面積規模		
	A > 3,000 ha	**3,000 ha > A > 1,000 ha**	**1,000 ha > A**
州を跨ぐ地区	中央政府	中央政府	中央政府
州　内	中央政府	州政府公共事業部	
県を跨ぐ地区	中央政府	州政府公共事業部	州政府公共事業部
県　内	中央政府	州政府公共事業部	県・市政府

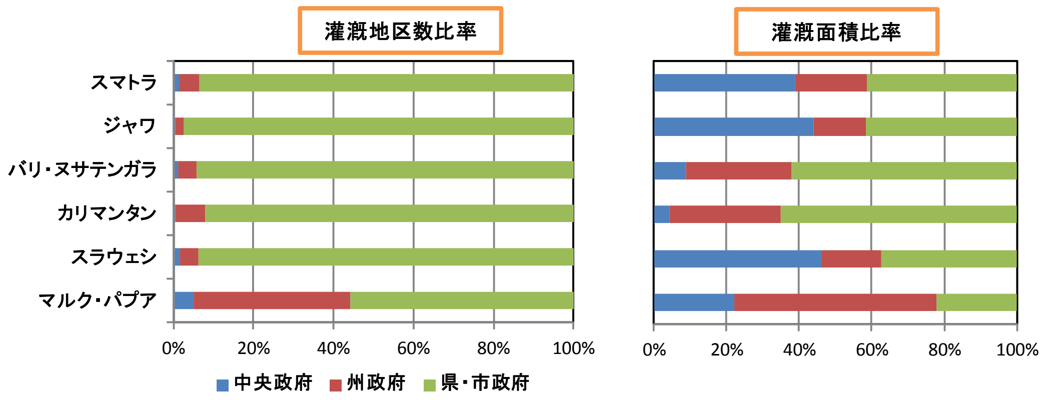
脚注:　表中の中央政府の実務は、公共事業省水資源総局の各流域管理事務所が担当
出典:　Government Regulation No. 20/2006 on Irrigation

8. 表流水灌漑地区数は全国で合計 33,226 地区存在し、上述した規模別・管理主体別の内訳は下表、地域ごとの地区数および面積比率は次図に示すとおりである。

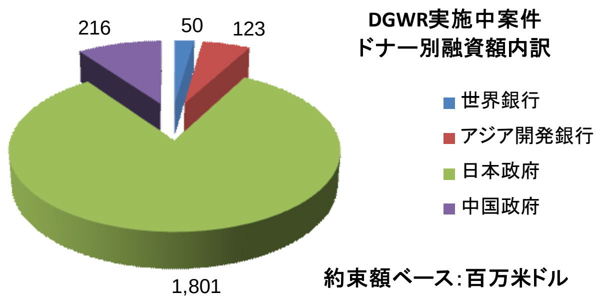
地　域	県・市政府				州政府			
	県内灌漑地区				県を跨ぐ灌漑地区		県内灌漑地区	
	A<100 ha		**100 ha<A<1,000 ha**		**A<3,000 ha**		**1,000 ha<A<3,000 ha**	
	地区数	面　積	地区数	面　積	地区数	面　積	地区数	面　積
	(nos.)	**(ha)**	**(nos.)**	**(ha)**	**(nos.)**	**(ha)**	**(nos.)**	**(ha)**
スマトラ	1,998	107.956	2,831	715,975	55	31,726	218	358,136
ジャワ	17,984	505,216	3,155	807,497	228	103,871	223	351,213
バリ・ヌサテンガラ	1,307	63,055	1,028	272,079	19	9,663	94	146,151
カリマンタン	276	17,094	1,031	307,728	0	0	106	154,408
スラウェシ	890	52,194	1,280	328,550	11	12,005	92	158,306
マルク・パプア	21	984	70	38,082	0	0	64	97,744
計	22,476	746,499	9,395	2,469,911	313	157,265	799	1,265,958

地　域	中央政府						合　計	
	県を跨ぐ灌漑地区		州内灌漑地区		州を跨ぐ灌漑地区			
	3,000 ha<A		**3,000 ha<A**					
	地区数	面　積	地区数	面　積	地区数	面　積	地区数	面　積
	(nos.)	**(ha)**	**(nos.)**	**(ha)**	**(nos.)**	**(ha)**	**(nos.)**	**(ha)**
スマトラ	7	141,489	56	541,049	3	93,364	5,168	1,989,695
ジャワ	38	743,041	54	590,943	5	55,613	21,687	3,157,694
バリ・ヌサテンガラ	9	37,699	19	10,667	0	0	2,476	629,314
カリマンタン	1	6,000	4	15,090	0	0	1,418	500,320
スラウェシ	10	121,685	29	349,181	0	0	2,312	1,021,921
マルク・パプア	0	0	8	55,185	0	0	165	191,995
計	65	1,049,914	170	1,652,115,	8	148,977	33,226	7,490,639

出典: DGWR database



9. これまで重点的に実施してきた各形態の水源を利用した新規灌漑開発事業に加え、2000 年代に入ってからは既存灌漑地区の改修・改良事業の実施に対しても、技術面のみならず資金面でも外国援助は大いに寄与している。DGWR を実施機関とする事業への融資は、主に世界銀行・アジア開発銀行・日本政府が行っているが、国際機関は地方分権に対応した灌漑施設の維持管理運営組織となる水利組合の育成強化や水資源セクターの法制度整備に援助目標を特化している。このため個別事業実施への融資は、日本政府が件数・事業規模・金額において最大の貢献をしている。現在、DGWR が実施中の外国借款案件に対する融資約束額のドナー別比率は下図のとおりである。日本政府の円借款を財源として 2000 年代末までに竣工した事業と現在進捗中の事業による累積灌漑面積は、計画灌漑面積ベースで 153 万 ha に達する。



10. 事業竣工後、灌漑施設の運営管理はインドネシア側の責務となり、項目 7 に述べた各段階の行政機関が二次水路までの基幹灌漑施設を運営管理するとともに、維持管理経費の予算措置を毎年講じている。また、三次水路を含む末端灌漑施設の維持管理活動と経費は受益農民が結成する水利組合の負担と灌漑法で規定されている。しかしながら、経費算出単価が計画灌漑面積 1 ha 当たり 15 米ドル前後に長年据置かれているため、灌漑地区施設維持管理費用に加え、人件費を含む維持管理担当業組織運営費、緊急補修用予備費などにも配分予算を充当する必要があることから、その結果として各段階の行政機関は所管灌漑施設の維持管理経費を十分に確保できない状況にある。

11. このような状況から、灌漑セクターが直面する主要課題は以下のとおりである。

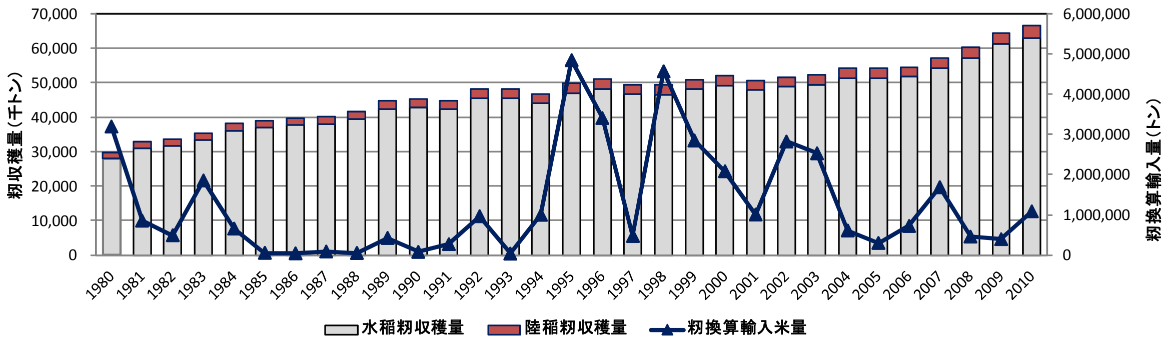
- 灌漑用水の適時均等配分に必要な灌漑施設改修対策策定・実施の促進
- 計画灌漑面積が未達成の灌漑地区においては、未整備灌漑施設の早急な完成
- 三次水路以下の末端灌漑施設維持管理活動へ農民の積極的な参加を促すため、プレキャストコンクリート板を用いた三次水路ライニングなどの補助・支援対策の策定・実施

・ 灌漑用水に利用可能な水源が限られてきたことから、効率的水利用に有効な節水稲作技術を普及するため、その前提条件となる圃場レベルの水管理を可能にする灌漑排水路網の機能向上対策の実施

食料安全保障政策の新たな展開

12. 中期国家開発計画 (RPJMN) 2005～2009 年の前半 3 年間における実績を踏まえて策定された RPJMN 2010～2014 年においては、インドネシア国民の主食であるコメの自給を確保するため、2014 年の生産目標は乾燥籾ベースで 7,570 万トンに設定された。

13. MOA および中央統計局の統計資料によれば、コメの生産量は 2007 年以降、下図のように毎年増加しているにも拘わらず、外国産米が継続的に輸入されており、2010 年後半から増勢に転じた輸入量は 2011 年には年間 150 万トン前後になり、国際コメ市場における最大の輸入国になる見込みである。

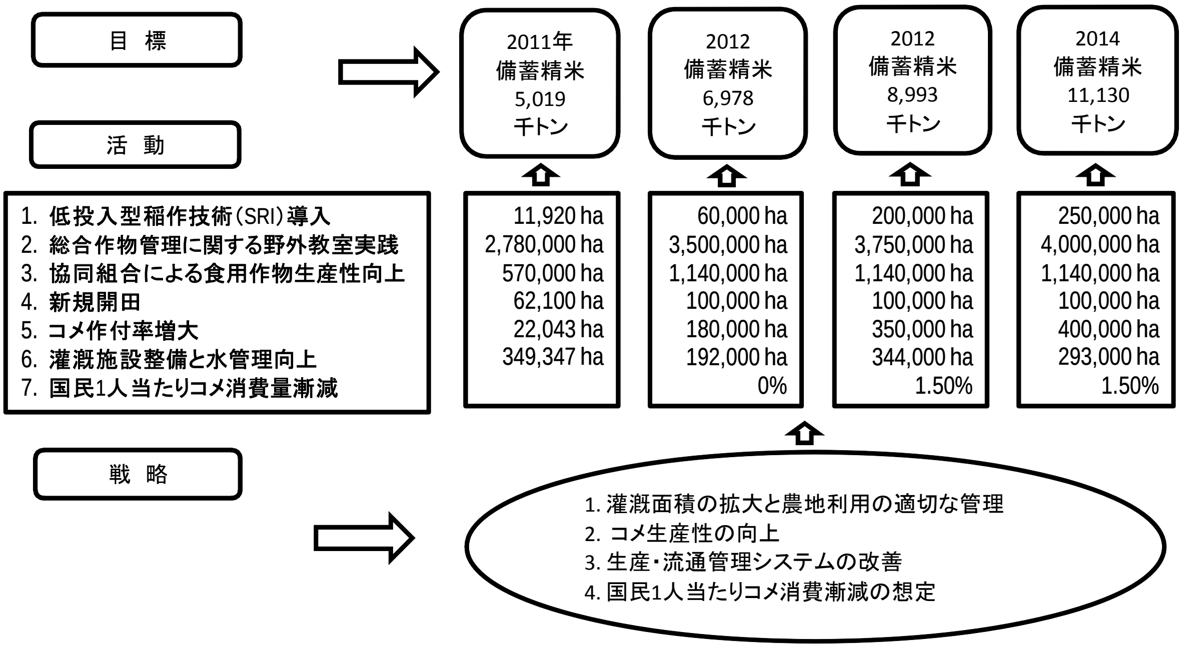


14. このような事態を懸念した大統領の指示により、2011 年 2 月から閣内関係副大臣クラスのグループで構成された委員会が食料安全保障強化方策の検討に着手した。グローバル気候変動の影響やインド洋大津波の教訓を踏まえた成案が「2014 年 1 千万トン備蓄に向けた国家コメ増産指針」として取りまとめられ、2012 年 1 月半ばに閣議で承認された。その中で、2014 年の籾生産量目標は備蓄精米 1 千万トンを含む 7,940 万トンへ上方修正されている。

暦年	予　測 人　口 (人)	1 人当たり 精米消費量 (kg/年)	精　米 需要量 (トン)	供給量 乾燥籾 (トン)	供給量 精米 (トン)	精米備蓄量 (トン)
2010	237,556,363	139.15	33,055,968	66,469,394	37,371,255	4,315,287
2011	241,095,953	139.15	33,548,502	68,596,415	38,567,136	5,018,534
2012	244,688,283	137.06	33,537,649	72,026,235	40,495,492	6,957,843
2013	248,334,138	135.01	33,526,799	75,627,547	42,520,267	8,993,467
2014	252,034, 317	132.96	33,515,954	79,408,924	44,646,280	11,130,327

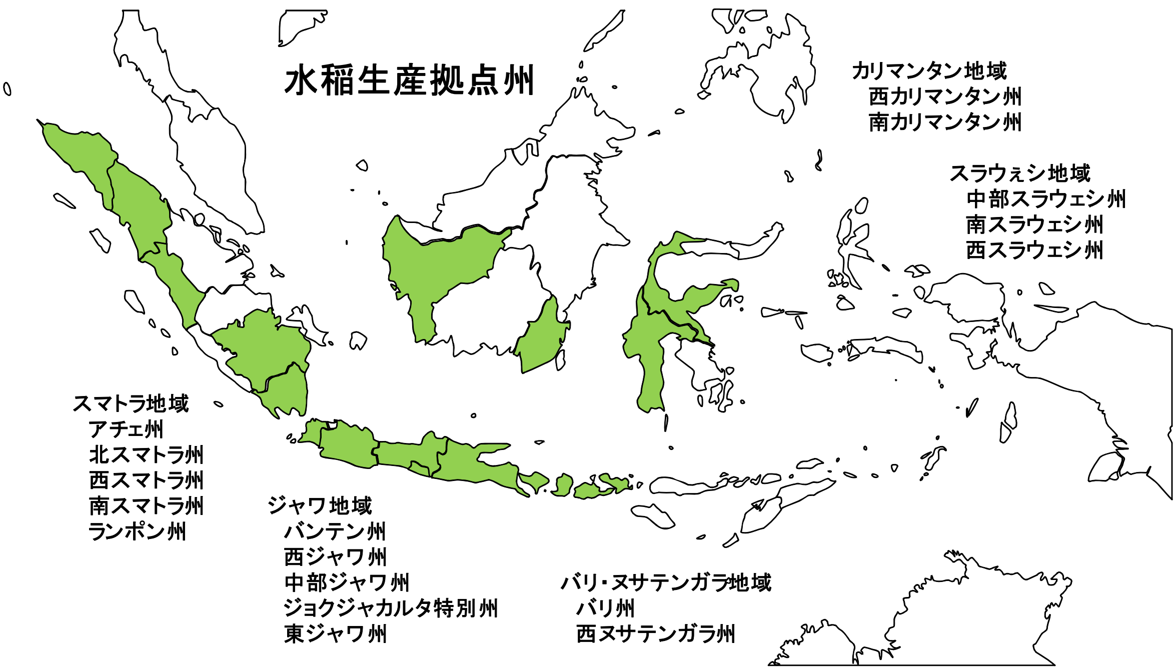
出典: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

15. 国家コメ増産指針の骨子となっている戦略と活動計画の概要は次図のとおりで、上流部分の戦略は優良農地保全・生産基盤整備・生産性向上、中流部分の戦略は収穫から小売に至る流通過程の損失量軽減、下流部分は所得向上に伴う食品への嗜好多様化を想定した国民 1 人当たりのコメ消費漸減の想定に焦点を定めている。この一連の戦略的骨格を前提に、縦割り行政の枠組み内でこれまで個別に実施されてきた各種のプログラムに選択と集中の原則を適用し、パッケージとして実施すれば相乗効果発揮が期待できる 7 項目を抽出し、活動計画の根幹としている。



16. 国家コメ増産指針に設定されたコメ生産目標達成のために、灌漑セクターには次の役割が課せられている。すなわち、2014 年までの 4 年間に初年度 2011 年の実績を含め、灌漑水路の整備 1,777,917ha、水源施設の改修 164,235 ha、表流水灌漑地区未整備施設の完工 86,435 ha、100 ha 未満の小規模灌漑地区の改修 109,000 ha、水管理合理化に必要な灌漑施設維持管理活動の強化 1,512,598 ha を実施することとしている。

17. 営農セクターにおいては、農民組合・水利組合を統合した協同組合を中軸に、総合作物管理に関する青空教室 (SL-PTT) 活動を通じて作物栽培方法全般の技術水準を底上げし、食用作物の生産性向上を図る。さらに、低投入型稲作技術 (SRI 農法) の普及活動を本格化することとし、下図に示す水稲生産拠点州を起点に、生産性向上に必要なセクター間および中央・地方間の協調体制の確立と強化を目指している。



18. 2014年に精米1千万トンの備蓄を達成するために、2010年の籾生産量から1,300万トンの増産を図ることとし、要素別増産効果の割合をSRI農法導入10%、SL-PTT実践58%、協同組合活動による食用作物生産性向上22%。新規開田1%、コメ作付け率増大7%、灌漑施設整備と水管理向上2%と見込んでいる。

19. 上述の増産目標達成には、水稲の1 ha当たり全国平均収量を籾ベースで2010年の6.0トンから2014年には6.8トンまで引き上げる必要があり、そのためには各要素に関し、特に以下の点を留意することが求められる。

- SRI農法導入を推進するために、農民の圃場レベル水管理技術習熟に不可欠な末端水路網(三次水路、大規模灌漑地区では四次水路) の整備に対する補助あるいは融資と施工管理への支援策を具体化すること
- SL-PTT 実践には、青空教室の指導役として村落単位に篤農家を起用・訓練・育成するとともに、高収量品種優良種子の普及促進、ハイブリッド米の導入、化学肥料偏重から有機肥料栽培への転換、広域統合病害虫対策の実施、収穫後処理作業の改善で構成されるパッケージ・プログラムの実行が増産目標達成の鍵となることから、青空教室の活動内容を受講農民の中核的担い手意識・意欲醸成に焦点を絞ること
- 協同組合による食用作物の生産性向上の前提条件として、村落内の農民グループ活動や水利組合活動の一本化を図るとともに、田植え・収穫時の伝統的な協働システムを発展させた村落基盤の協業・請負耕作システムを推進すること
- 新規開田および作付け率増大には灌漑用水の水源手当が不可欠であることから、対象地区の選定にはコメの生産現場をつかさどる県知事・市長の指揮下で、DGWR 流域管理事務所・州政府・県および市当局の水資源・灌漑と農業担当者の協調体制を確立し、個別灌漑地区において作付け計画および灌漑用水配分計画を実施する過程で生じる諸問題の解決に向けた柔軟な対応を可能にすること
- 灌漑施設整備と水管理向上の一環として、現在進捗中の円借款灌漑事業を施工計画に従って完成させ、計画灌漑面積133,260 haを実現させるとともに、既存灌漑地区単位で施設状況・灌漑用水供給状況・作付け状況・作物生産量に関する最新情報の共有化を図るため、既に枠組みができあがっているDGWRのデータベースを活用し、実態に即した維持情報を関係組織から定期的に収集・入力の上、農民のニーズに対応した事業計画策定に関係者が共同で対処できる情報源を構築すること
- 国民1人当たりのコメ消費量は可処分所得水準で異なることから、国民を所得上位層・中位層・下位層・貧困層に区分した場合、経済発展の恩恵を蒙って貧困層から所得下位層に移行した者は従来以上に多くのコメを消費するようになる。その一方で、所得上位層のコメ消費量は食事内容の多様化によって減少が見込まれる。したがい、双方の増減量の差分が国民1人当たりのコメ消費量動向を決定する主要素となることから、BAPPENASが毎年2月に公表するマクロ経済実績の中で示される可処分所得水準動向に準拠し、目標数値の更新ついて柔軟に対応すること

灌漑用水の最大利用

20. インドネシアにおいては、表流水灌漑地区の90%近くは水源河川の自流量を取水しているため、乾期稲作灌漑用水の必要水量を安定的に確保できないリスクを大なり小なり抱えている。

その一方で灌漑用水の水源が手当てされているにも拘わらず、農作物の灌漑栽培、特に灌漑稲作に使われていない既存灌漑地区のほぼ全部は、施設の機能低下あるいは機能不全などの物理的障害に起因して灌漑用水が地区の一部に全く供給されていない、あるいは所定の水量の一部しか供給されていない状態におかれている。したがい、水源手当てが十分になされ、かつ基幹灌漑水路網も完全に機能しているにも拘わらず、利水者不足により灌漑用水の一部が未利用となっている既存灌漑地区は例外的存在である。また、項目 6 に示した過去 15 年間の水源形態別・地域別面積の推移から明らかなように、湿地帯に開発された入植地の農民が排水不良あるいは過剰排水による土壌強酸性化などが起因して 1 ha 当たり 1.0 トン未満の低収量しか得られぬ水稲栽培を断念し、MOA の小規模永年作物振興プログラムを活用してオイルパーム栽培に転換したことから、スマトラ・カリマンタン・スラウェシ地域において潮汐灌漑地区の面積が 15 年間に半減して 104 万 ha となっている。一方、過湿土壌を好まぬゴムを離農者が天水田に新植して離村する事例はスマトラ地域で散見され、さらに全国各地の灌漑事業実施地区では施行段階で水路建設用地買収や三次以下の水路建設用地の無償提供に地権者の同意が得られず、路線変更や建設を断念した事例もすくなからず見受けられる。それ以上に問題視しなければならないことは、ジャワ地域を中心に大都市周辺で生産性の高い優良水田の農外転用への法的規制が形骸化し、転用農地面積やそれに伴う利用されなくなった灌漑用水量が具体的数値として把握されていない事態である。

21. 2010 年に DGWR が実施した灌漑施設機能簡易調査結果によれば、1999 年以降の 11 年間に機能良好な表流水灌漑地区の総面積は下表のように約 30%減少して 348 万 ha となり、その分が機能低下地区へ移行して 304 万 ha、機能劣化地区も 71 万 ha にそれぞれ増えている、

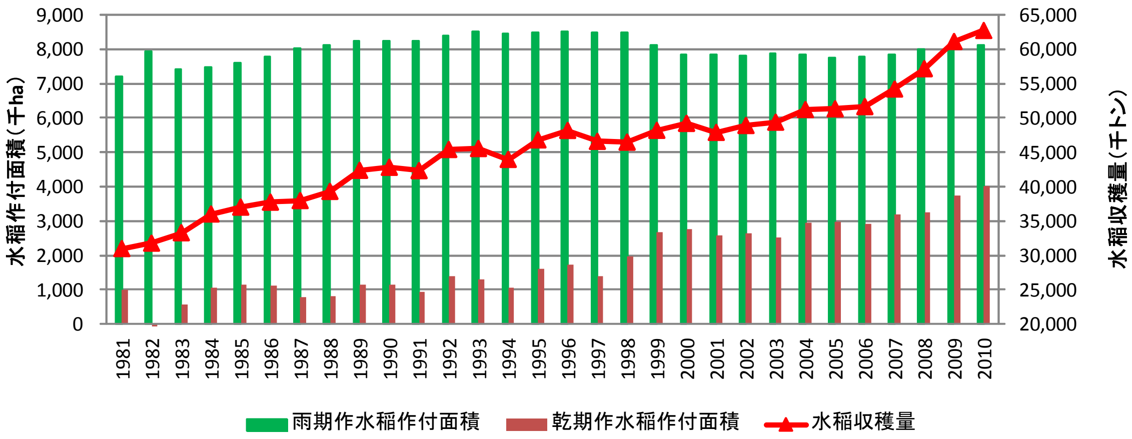
施設機能状態	1999 年		2010 年	
	(ha)	(%)	(ha)	(%)
良好	5,254,951	77.6	3,481,298	48.1
やや良好・低下	1,389,938	20.5	3,043,313	42.1
劣化	126,127	1.9	705,572	9.8
合　計	6,771,016		7,230,183	

出典: MPW, 2011

22. 他方、中央統計局公表の農業土地利用および水稲収穫面積統計資料に基づき、年間水稲収穫面積から水田面積を差し引いた面積を水稲の乾期栽培面積と推定すれば、次図のようにその面積は 1999 年から 11 年間に約 40%増加して 401 万 ha となり、かつ水稲年間収穫量も乾期作を主体にこの 11 年間に約 30%、1,450 万トン増えた。これら乾期作水稲栽培面積と収穫量の増加は、この期間に竣工して灌漑用水の供給を開始した灌漑開発事業によるところが大きい。また国家コメ増産指針においては、MOA および中央統計局の資料に基づいて 2010 年現在の全国水稲作付け率別水田面積を次のように推計している。すなわち、作付け率 200%以上の水田 175 万 ha、作付け率 150%～200%の水田 216 万 ha、作付け率 100%～150%の水田 122 万 ha、作付け率 100%以下の水田 298 万 ha、全水田面積 811 万 ha の 22%を水稲二期作完全実施水田と見做している。

23. これらの状況を踏まえ、既存灌漑地区を以下の 3 類型に大別し、灌漑用水の最大利用について検討を行うこととする。

- 類型-1：乾期灌漑水源が十分かつ持続して確保されており、地区全体で水稲の灌漑二期作が実施可能な地区



出典: Data base of Ministry of Agriculture

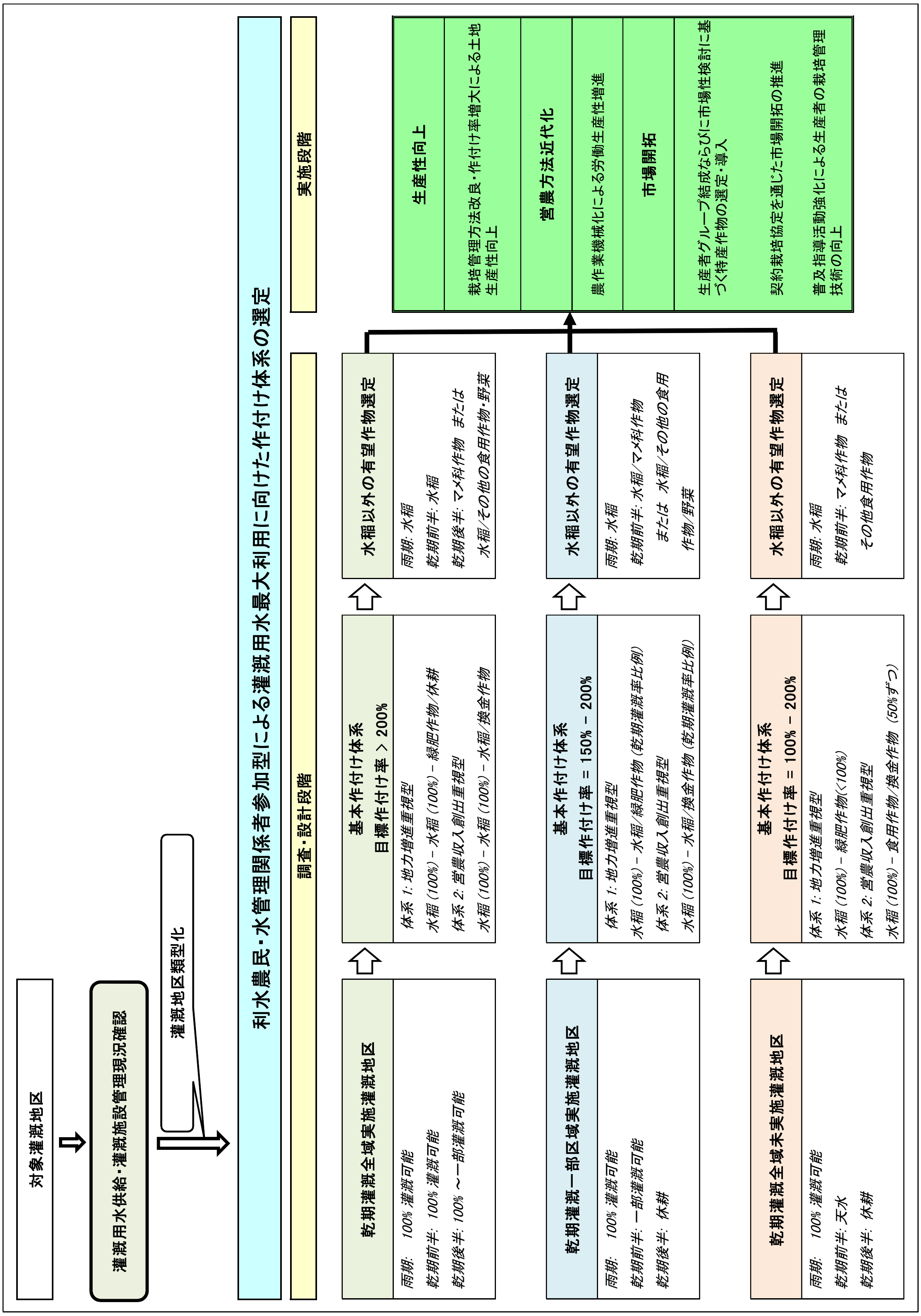
- 類型-2：乾期灌漑水源が不安定なため、地区の限られた範囲でのみ水稲の灌漑二期作が実施可能な地区
- 類型-3：乾期灌漑水源が手当てできないか、あるいは施設機能停止により、雨期作水稲への補給灌漑に限定された地区

24. 農業用水の最大利用を図る手段として、上記 3 類型ごとに国家コメ増産指針に即した作付け体系を検討した。その結果は以下のとおりで、灌漑用水最大利用に係る作付け体系検討概念を次図に示す。

- 類型-1 地区：国家コメ増産指針の第 5 活動計画の作付け率増大に最力点をおき、乾期の灌漑用水に余裕があれば、乾期作水稲の収穫後に生育期間の短い品種の水稲の灌漑栽培を行い、灌漑用水の最大利用を図る。さらに、水稲の通年栽培による害虫発生の温床化防止に効果的な稲作中断期間を広域で設ける対策、地力維持対策、零細規模稲作農家の収入源多様化対策として、隔年で乾期後半に休耕、緑肥作物栽培、換金作物栽培をそれぞれ実施する。
- 類型-2 地区：乾期灌漑水源の安定化には、貯留機能をもつ水源施設の整備や流域の水源涵養力回復・強化が最も有効な手段であるが、いずれも中長期的な取り組みが必要となる。したがい、当面あるいは恒久的に乾期作灌漑用水を必要量確保できない地区においては、国家コメ増産指針の第 1 活動計画の SRI 農法導入および第 6 活動計画の灌漑施設整備と水管理向上のうち、水源施設改修・表流水灌漑地区未整備施設完工・100 ha 未満の小規模灌漑地区改修・水管理合理化に必要な灌漑施設維持管理活動強化に焦点を定め、有限な灌漑用水の高度利用と乾期作水稲灌漑栽培面積の拡大を通じて灌漑用水の最大利用を図り、かつ類型-1 と同じ営農対策を乾期作期間中に実施する。
- 類型-3 地区：国家コメ増産指針の第 6 活動計画のうち灌漑水路の整備が大前提となり、その効果として乾期作水源の一部が確保できれば、類型-2 と同様の活動計画実施を通じて灌漑用水の最大利用を図る。

25. インドネシアで栽培されている主要作物の一作 1 ha 当たりの収益性についてコメの指標を 100 として比較すると、2011 年時点で赤タマネギ 318＞トウガラシ 255＞キャッサバ 250＞ナス 107＞コメ 100＞トウモロコシ 93＞落花生 85＞サトウキビ 83＞ゴム 80＞インゲン豆 71＞オイルパーム・キュウリ 62＞緑豆 40＞大豆 36 となる。一方、農作業投入労働力 1 人当たり

の収益性はオイルパーム 299＞ゴム 180＞キャッサバ 157＞トウガラシ 150＞インゲン豆 144＞赤タマネギ 141＞キュウリ 135＞サトウキビ 123＞トウモロコシ 117＞落花生 110＞コメ 100＞ナス 98＞大豆 73＞緑豆 66 となる。



出典: JICA 調査団

なお、ゴムは植栽後 19 年間、オイルパームは植栽後 24 年間、サトウキビは作付け期間 3 年間の年間収穫量平均値を用いた。コメと永年作物のゴム･オイルパームの特性は対極にあり、本調査で行ったスマトラ地域バタンハリ灌漑地区・ワイスカンポン灌漑地区、ジャワ地域チウジュン灌漑地区、スラウエシ地域ビリビリ灌漑地区の農民聴取でも、農作業の労を厭わぬコメ栽培農家は灌漑用水を最大限に利用して二期作や三期作を行えば、永年作物の 2 倍から 3 倍の現金収入機会を確保できる稲作を志向し、その一方で投入した労働力に見合った収益と認識している永年作物栽培農家は年 1 回の現金収入でも満足している傾向が確認された。

26. 灌漑用水源に余裕があれば、既存灌漑地区内あるいは隣接地に計画灌漑対象地に含まれていない湿地や排水不良の凹地を利用して淡水・汽水養魚池を新設し、これに既設灌漑水路から養魚用水を供給することにより、灌漑用水の活用を高めることが可能となる。灌漑法の規定を満たした養魚池向け養魚用水は、水田向け灌漑用水とは別枠で供給されるため、水源の余裕分の利用に限定すれば、計画灌漑水田面積を減少させる事態は発生しない。また、双方の排水が互いの用水路に混入することを防ぐように用排水路を配置することにより、水質汚濁問題のリスクを回避できる。淡水養魚池への供給水量は、通常の養殖池管理条件（養殖魚種テラピア・フナ・ナマズ、年間養殖回数 2 回、毎回の養殖期間 150 日終了後に落水・池底清掃・入水、水深 1.5 m、日補給水量を水田と同じ水面蒸発量・浸透損失量の合計値と仮定、曝気装置使用）で最低 4 L/s/ha 弱を要することから、標準的単位要水量として余裕を見込んだ 6 L/s/ha が適用されている。一方、汽水養魚池への養殖用水供給は淡水補給を目的としているため、標準的単位要水量として 1.2 L/s/ha が適用されている。淡水・汽水養魚の収益性は魚種によって異なり、コメ二期作の収益性指標を 100 として年 2 回分の漁獲収益と比較すれば、テラピア 351、コイ 155、ナマズ 104、金魚 14 となるが、養魚池造成費初期投資の自己負担額が大きく、稚魚・飼料・薬品の調達に高額の現金支出を要し、代替水源手当を含め水量・水質管理経費も嵩むことなどリスクも大きい。水源および立地条件に恵まれた灌漑地区において水田以外の土地に養魚池を新設して内水面養殖を実施するには、農家の副業規模あるいは専業規模の如何に拘わらず、灌漑法の規定に従って行政機関から灌漑用水の利用権を取得し、当該灌漑地区所管の県灌漑委員会が毎年作成する灌漑用水配水計画の対象地区としての登録が必要となる。

27. インドネシア政府は、そのエネルギー長期計画の最終目標年次 2025 年にエネルギー消費量の 5.1%をバイオ燃料で充当するため、オイルパーム・ジャトロファ・サトウキビ・キャッサバを原料作物として選択している。このうち、オイルパームは湿地、ジャトロファは乾燥地に適応した永年作物であり、バイオディーゼルの原料となる。それぞれの作物特性により、苗木植え付け時から幼木・成木管理段階に至るまで灌漑を必要としないため、灌漑用水の利用度を高める作物の対象外となる。サトウキビとキャッサバは水田・畑地のいずれでも栽培可能であり、バイオエタノールの原料となる。サトウキビは製糖過程で生じる副産物の糖蜜を原料として、商業ベースでバイオエタノールを生産する工場がランポン州において稼働中であるが、サトウキビの搾汁から直接バイオエタノールを生産するシステムは導入されていない。インドネシアにおいては、サトウキビの苗を植え付け後に灌漑を行い、生育速度をはやめることによって 12 か月目に収穫が可能となり、水田に作付けをした場合には年単位で水稲との輪作体系が導入できる。また、乾期中の消費水量がコメより少ないため、その差分を水田に供給すればサトウキビ栽培による乾期稲作面積減少分の幾分かは取り戻せる。灌漑水源に余裕があり、サトウキビ栽培が可能な畑地が灌漑地区に隣接して分布し、収穫後処理の時間的制約内に製糖工場が存在する条件を具備した灌漑地区であれば、サトウキビ栽培は灌漑用水の利用度を高める有効な手段となり得る。農民がサトウキビの灌漑栽培を営農形態に取

り入れる場合には、所在する県の灌漑委員会に申請して灌漑対象地区として登録することが必要となる。キャッサバは土壌条件に左右されず生育可能な利点と食品加工・飼料生産向けの汎用性を持ち、市況も好転していることから、乾期作灌漑水源が手当てできない灌漑地区の水田の裏作として、近年栽培面積が拡大傾向にある。しかし、キャッサバを水田で栽培すると収穫時に水田の耕盤を破壊、その結果として浸透損失水量と灌漑単位要水量を増大させるため、灌漑用水の利用度を高める観点から、推奨可能な有望作物対象となり得ない。また、バイオエタノール生成原料であるキャッサバ澱粉絞り滓加工技術の実用化には相当の時間がかかるものと見込まれている。

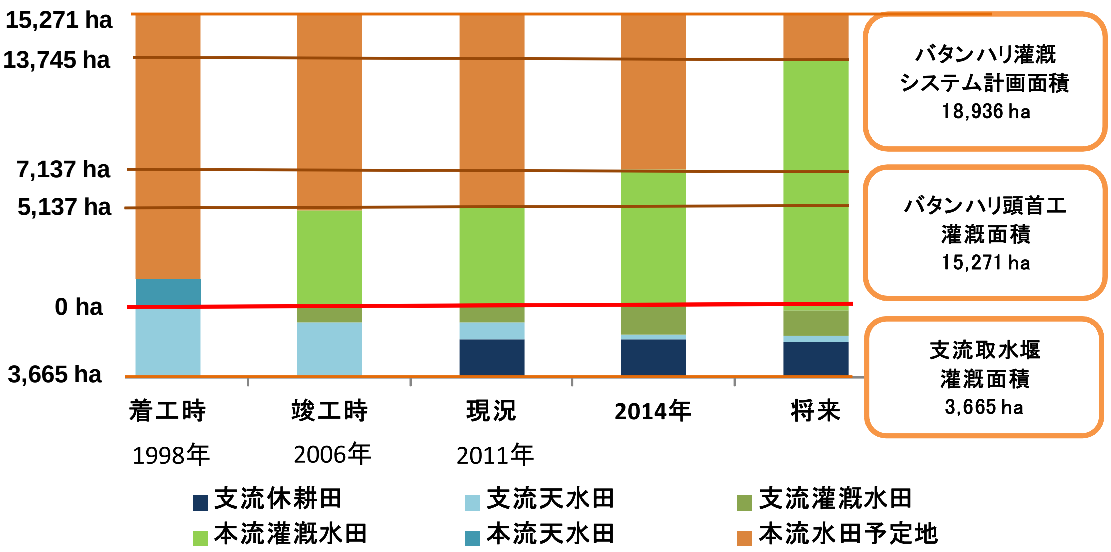
バタンハリ灌漑地区における灌漑の現状と将来計画および小水力発電計画の可能性検討

28. バタンハリ灌漑地区における稲作は、ジャワ島中部のウオノギリダム建設に伴う貯水池水没地域から 1970 年代後半に集団移住してきた約 4,000 世帯の農民によって始められ、1988 年までにジャワ地域から追加移住した約 3,000 世帯によりさらに拡大した。当初入植世帯に割り当てられた天水田約 3,000 ha の水源対策として世銀資金によりバタンハリ川本流にポンプ場 1 か所、支流に取水堰が 3 か所新設された。その後のオイルショックによる燃料代高騰からポンプ場運転経費が嵩み、入植地水田への灌漑用水供給が不安定な状況が常態化していた。この事態を打開する目的で、1980 年代から構想されていたバタンハリ川本流に頭首工を新設する計画が具体化し、1993 年 11 月に調査・詳細設計業務に対して円借款が供与され、引き続いて 1998 年 1 月に締結された円借款供与により第一期事業として頭首工および幹線水路上流区間と下流区間の建設工事が 1998 年に着手された。残余の幹線水路中流区間は 2001 年 7 月に供与が決定した円借款で建設され、バタンハリ入植地区への灌漑用水供給は計画着手後 12 年が経過した 2006 年 5 月に実現した。

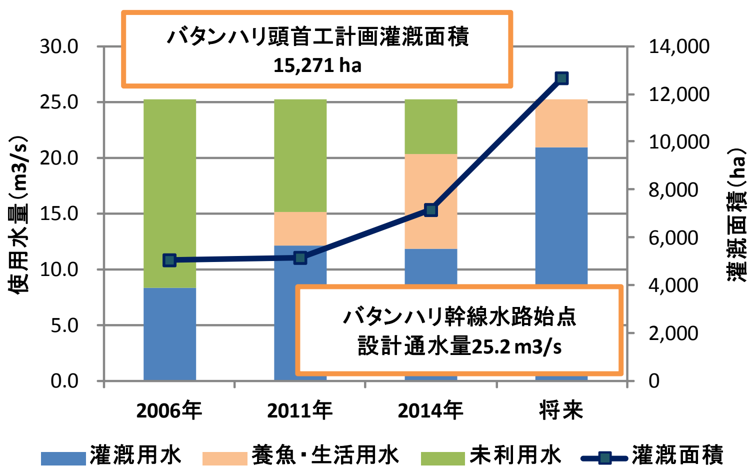
29. バタンハリ灌漑システムは、バタンハリ川本流の頭首工、3 支流の既設取水堰、合計 4 か所の水源施設から灌漑用水を取水し、計画灌漑地区 18,936 ha に供給する計画で事業が着手されたが、2008 年の竣工時における灌漑可能面積は 5,836 ha にとどまった。その内訳は、バタンハリ頭首工を水源とする灌漑区域計画面積 15,271 ha に対する竣工時の灌漑面積が 5,036 ha、3 支流取水堰を水源とする灌漑区域計画面積 3,665 ha に対する竣工時の灌漑面積が 800 ha である。竣工時の実績灌漑面積が当初計画を大幅に下回ったのは、幾つかの要因が重なって生じたものである。これらの要因を時系列で整理すると、第一に、1980 年代から構想されていたバタンハリ灌漑システム計画が具体化した段階から、将来の受益農民に対する情報開示が不十分であったため、農民の間に事業実現への疑念が生じたこと、第二に、幹線水路上・中流区間沿いの丘陵地に入植した稲作経験に乏しい地元入植者を対象にした灌漑農業への参加を促す啓発活動が早くから実施されなかったこと、第三に、入植者 1 世帯ごとに配分された水田利用が可能な土地 0.5 ha、畑地利用が可能な土地 1.0 ha、居住用地 0.5 ha、計 2.0 ha のうち、畑地部分を対象にした政府の貧困農民向け支援プログラムによる小規模ゴム栽培への参加者が 2003 年以降のゴム市況高騰に触発されて急激に増加したこと、第四に、その帰結としてバタンハリ計画灌漑地区 18,936 ha の約 75%を占める畑地・未耕地・ゴム林を対象にした水田造成事業への農民の参加意欲が減退し、三次水路開削用地の提供に応じない農民もかなり存在し開田が進まなかったこと、が挙げられる。

30. 2004 年に新設されたダルマスラヤ県はバタンハリ灌漑地区を経済基盤とし、2010 年の人口センサスによれば全人口 186,354 人、全世帯数 56,000 戸の 62%が水稲栽培を生業に、ゴム栽培でも副収入を得ており、29%がゴム栽培に従事している。竣工後 3 年が経過した 2011 年現在、灌漑水田面積は 101 ha 増えて 5,937 ha となり、灌漑用水が供給されている淡水養魚池 257 ha

が稼働している。灌漑水田のうち 5,137 ha がバタンハリ頭首工・幹線水路から年間を通じて灌漑用水の供給を受けている。そのうち、水稲三期作実施面積が 2,260 ha に達し、残り 3,057 ha も二期作が行われ、稲作農家は灌漑用水を高度に利用して、農業所得向上を実現している。一方、支流取水堰灌漑地区においては受益面積 3,665 ha のうち 800 ha が灌漑水田、620 ha が天水田、残り 2,245 ha は休耕田、その一部は農外目的に使用されている。2010 年のバタンハリ灌漑地区における水稲の平均収量は 1 ha 当たり籾で 4.45 トン、年間総収穫面積 13,555 ha から約 62,000 トンの籾を産出している。灌漑稲作が開始されてから 7 作目ないし 8 作目で熟田化がすすみ、計画目標収量の雨期作 4.5 トン、乾期作 5.0 トンの水準に近付いており、一部の地区では 6.0 トン前後に達している。ダルマスルヤ県知事は 2010 年 6 月に締結した DGWR 総局長との合意書に基づき、県の現行中期開発計画期間中 (2010 年～2014 年) に、1) バタンハリ頭首工灌漑地区において合計 2,000 ha の新規開田、2) 支流取水堰灌漑地区の天水田 620 ha への灌漑施設修復、3) 既存 257 ha の淡水養魚池に加え、443 ha の新規拡大、4) 灌漑用水を水源とする小規模生活用水供給システムの新設を行うことを政策目標に定めている。バタンハリ灌漑システム着工以来の水田面積推移を下図に示す。



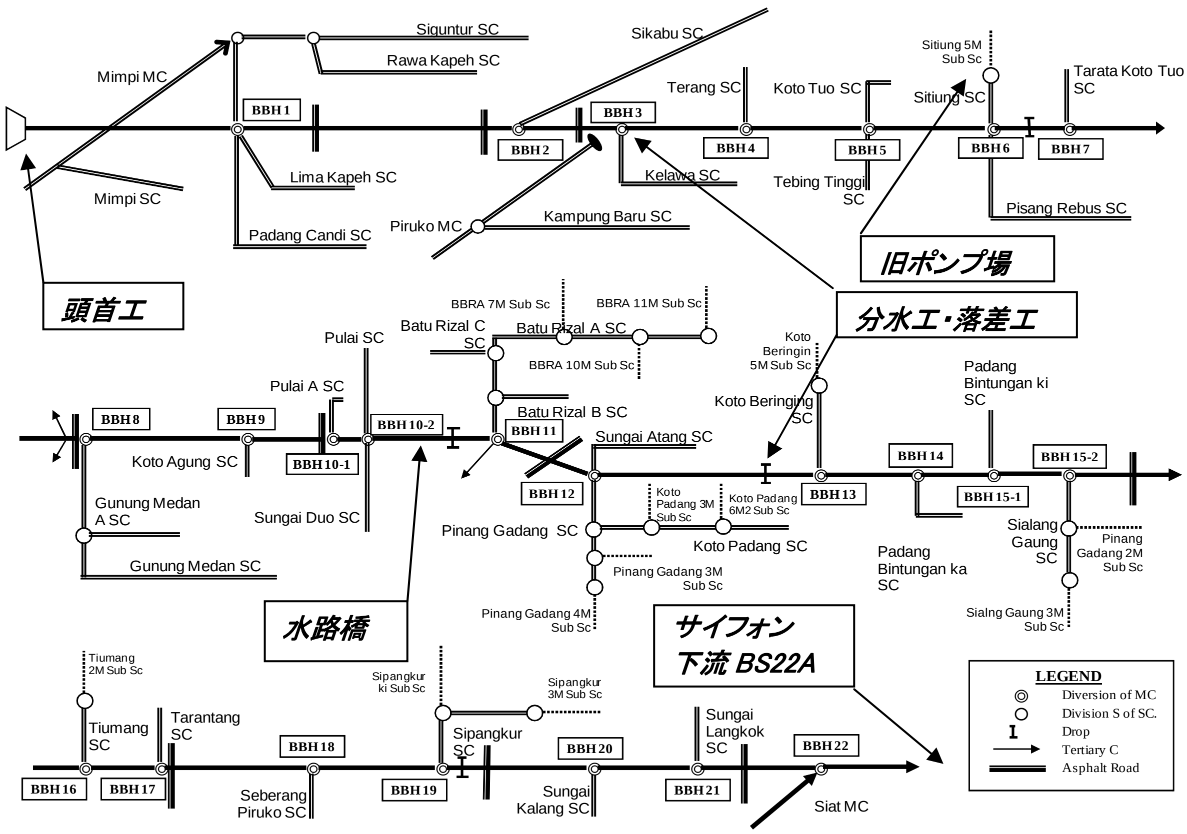
31. バタンハリ頭首工の設計最大取水量 30.2 m^3/s、幹線水路始端の設計通水量 25.2 m^3/s、計画灌漑面積 15.271 ha に対し、現況灌漑面積 5,317 ha および上述の計画達成時の灌漑面積 7,137 ha の水利用状況を右図に示す。2014 年に上述の開発目標が達成された場合、それ以降バタンハリ幹線水路の未利用水による灌漑可能面積は 2,970 ha となる。また、合意書においては小規模生活用水供給量を 0.12 m^3/s、養魚池供給水量を 12.0 L/s/ha と設定している。前者は、バタンハリ地域の経済活動中心地であるシティウン郡の生活用水需要を満たすため、インドネシア政府の地方給水計画基準 (給水人口 1 人当たり 60 L/hr) を踏まえて



算定された 2026 年予測給水人口 13,700 人に対する所要水量である。後者は、淡水養魚池への標準的単位要水量 6.0 L/s/ha と比べて過大に設定されているため、これを半減すれば灌漑面積をさらに約 3,600 ha 増やせる余地がある。

32. バタンハリ灌漑地区において灌漑用水さらに活用するためには、ダルマスルヤ県政府による地元農民への啓発活動を持続して稲作への関心を醸成するとともに、新規開田 2,000 ha の実現に向け、DGWR の出先機関スマトラ第 6 流域管理事務所を通じて灌漑セクター最重要課題の灌漑施設整備･水管理向上プログラムにバタンハリ灌漑地区を組み込むことを DGWR に要請し、事業実施に必要な財源の確保を最優先して行うことを提案する。さらに、開田事業参加農民へのフォローアップ対策として、各種営農支援プログラムをパッケージ方式で実施する SL-PTT 活動適用をダルマスルヤ県政府から MOA に申請する。また、この活動を実効あるものとするため、既に稲作を生業としている地元入植者からリーダーシップを備えた若い農民を指導員として訓練・活用するとともに、ダルマスルヤ県知事の指揮下で関係者による活動の相乗効果を発現するための協調体制の構築が必要となる。既存灌漑地区においても、篤農家を中心としたグループ営農活動を推進し、地区ぐるみの農業生産体制確立に向けた取り組みが不可欠となる。

33. ダルマスルヤ県政府で構想しているバタンハリ地区の灌漑用水を使用した水力発電計画の検討に当たり、可能性のある地点として次図に示す頭首工、幹線・支線水路上に設置された分水工・落差工・水路橋・サイフォンなどの水路構造物、現在遊休施設化している旧ポンプ場を選定した。本調査では、これらの地点における小水力発電事業の導入可能性について技術的・経済的観点からプレフィジビリティー段階の検討を行った。検討結果の概要は以下のとおり。



・ 国営電力公社 (PLN) は、民間発電事業者の再生可能エネルギー発電設備を対象にスマト

ラ地域の 1 kWh 当たり買電価格を、地域別調整分も含めて低電圧接続の場合 1,205 ルピア、中電圧接続の場合 787 ルピアに設定し、PLN 送電網に接続させる送電線建設費用は当該事業者の負担としている。この価格に基づく低電圧発電施設に対する投資の損益分岐点は、現時点で発電単価 1 kW 当たり 3,000 米ドルと試算される。

・ バタンハリ頭首工：対象地点背後の丘陵地を掘削して施設を建設する必要があり、2,000 kW の発電量が期待できるものの、建設費用がかさみ、発電単価は 1kW 当たり 4,800 米ドルに達して経済性が確保できない。

・ 分水工・落差工・サイフォン：幹線水路から灌漑地区 15,270 ha の地区に対する当初の配水計画に影響を及ぼさない発電設備を想定した場合、有効落差はいずれも 2 m 以下で、発電量は最大 10 kW にとどまり、各種の超低落差向け発電機を導入しても、発電単価は 1 kW 当たり 4,000 米ドルとなり、経済的に採算がとれないことに加え、内部に挿入可能な発電用小型タービンはインドネシア国内で入手不可能である。

・ 水路橋：幹線水路に 1 か所設置されている水路橋地点では、有効落差 9.5 m が確保できるが、PLN 送電網に接続させる送電線延長が 800 m となること、発電設備設置敷地の用地買収と発電所建屋の新築を要することに加え、発電に分水した灌漑用水を再利用するための揚水設備費を加えれば、投資額に見合う経済性は見込めない。

・ 旧ポンプ場施設：有効落差 19.0 m を確保でき、PLN 送電網との接続距離も 200 m で済む立地条件を備え、水利用効率を考慮した発電通水量を 5 m^3/s と設定した場合の発電容量は 420 kW を期待できるが、写真に示すように建屋本体の改修工事とペンストックの一部取り換えが必要となる。


上部より見た旧ポンプ場と
一部破損したペンストック


旧ポンプ場一部破損天井


旧ポンプ場下流側全景


旧ポンプ場内部

34. 以上の小水力発電可能性地点の比較検討結果を踏まえ、旧ポンプ場施設の利用可能性についてさらに検討するため、バタンハリ幹線水路の灌漑用水利用方法につき、当初の計画灌漑面積に影響を及ぼさぬ基本シナリオと灌漑用水の一部を発電目的に使う代替シナリオの二案を比較検討した。基本シナリオの発電使用水量は、旧ポンプ場への分水工地点における通水量 21.55 m^3/s とその下流灌漑地区 13,062 ha で使用する用水量との差分となり、代替シナリオの発電使用水量は、現在の下流地区実績灌漑面積と 2014 年までの追加面積を合わせた 5,318 ha への灌漑用水に淡水養魚池 595 ha への給水、小規模生活用水供給量の合計水量との差分となる。検討結果は以下のとおりで、基本シナリオに灌漑用水の目的外使用量を増やすほど採算性が向上する。また、灌漑用水需要ピーク時に代替シナリオは基本シナリオより灌漑用水を 4.90 m^3/s 余分に使用し、これによって灌漑面積が 2,970 ha 減少する計算となるものの、前述のとおり過大に設定された淡水養魚池の使用水量を一般的な水準である 6.0 L/s/ha に設定すれば。灌漑面積の減少は起こらない見込みである。さらに、代替シナリオは分水した発電使用水量を灌漑用水需要形態と無関係に専用できるが、基本シナリオの発電使用水量は灌漑用水需要量と連動して決まることから、下流灌漑地区において予め設定された作付け計画の順守とそれに対応した灌漑システムの適切な運用が必要となる。

	分水地点下流 灌漑面積(ha)	発電使用 水量(m3/s)	年間発生平均 電力量(MWh)	経済的内部収益率 EIRR （%）
基本シナリオ	13,062	7.43	2,723	10.0%
代替シナリオ	5,318	8.19	3,532	21.1%

35. 灌漑用水の農外利用を目的とした事業構想を検討するに当たり、水資源行政上の枠組みの中で技術的・経済的な可能性を検討する方針に即し、農外目的で使用した灌漑用水を当該灌漑地区において再利用する対策も含めることとした。その場合、代替シナリオにおいて、発電後にバタンハリ川に放流した灌漑用水の再利用に必要な揚水設備を新設し、その動力源として発生電力を用い、かつ採算性を確保するためには、再利用施設用地とバタンハリ灌漑水路網の揚程を 1.5 m 以内にする必要がある。一方、旧ポンプ場下流のバタンハリ川水面とバタンハリ灌漑地区水路網との標高差は最低でも 5 m あり、代替シナリオの経済性を確保できるような再利用施設建設地点は見当たらない。したがい、農外目的で使用した灌漑用水を当該灌漑地区において再利用を想定する場合、余剰水を利用する基本シナリオのみが、さらなる投資検討対象となる。

結論と提言

36. 2007 年現在､インドネシア全国には計画灌漑面積基準で合計 877 万 ha の水田が灌漑可能となっている。このうち、河川を水源とする表流水灌漑システムは 33,226 地区存在し、合計面積は 723 万 ha、計画灌漑総面積の 82%を占めている。また、貯水池・溜池などの調節機能を持つ水源施設から灌漑用水が持続的に供給されている表流水灌漑システムの面積は合計約 80 万 ha にすぎず、乾期作水稲の栽培面積拡大・安定に対する制約要因の一つになっている。灌漑システムの管理主体は地方分権に即して規模および行政区域を基準に中央・州・県の各段階の政府組織が分担しており、中央政府では公共事業省水資源総局が全国か所に設置した流域管理事務所、州および県政府では灌漑関係業務を分掌する組織が、それぞれ分担する灌漑システムの管理主体となっている。インドネシア政府がこれまで実施してきた新規灌漑開発事業や既存灌漑施設改修改良事業に対し、国際機関および日本政府が多大な資金援助と技術協力を供与してきた。なかでも、個別灌漑事業実施への融資には、日本政府が最大の貢献を

しており、完工・進捗中の事業による累積灌漑面積は計画数値基準で 153 万 ha に達する。事業竣工後の灌漑システム維持管理業務は上記管理主体の責務となり、所管する全灌漑システムの維持管理活動を一元的に統括している。各管理主体が維持管理費の予算措置を講じているが、全体的に必要経費が不足し、その結果として施設が良好に機能している灌漑システムの面積が過去 11 年間に約 30%減少する事態を惹き起こしている。

37. インドネシアのコメ自給量は、灌漑システムの整備によって乾期稲作面積が拡大し、2007 年以降増加傾向を維持しているにも拘わらず、毎年 50 万トンから 100 万トンの外国産米を輸入している。このため、大統領指示により、2011 年 2 月から政府関係組織が共同で食料安全保障強化対策の検討を開始し、2012 年 1 月にその成案が「2014 年 1 千万トン備蓄に向けた国家コメ増産指針」として閣議に報告・了承された。指針では、灌漑と農業を中核としたセクター間の連携体制と地方分権下で中央・州：県各段階の関係組織の協調体制を構築するとともに、縦割り行政の枠組み内でこれまで個別に実施されてきた各種のプログラムから、パッケージとして実施すれば相乗効果発揮が期待できる 7 項目を選択し、集中的に実行する活動計画が策定されている。向う 4 年間に籾の全国平均収量を 1 ha 当たり 6.0 トンから 6.8 トンに引き上げ、1,300 万トンの増産を達成するため、その生産基盤強化に必要な灌漑分野のプログラムとして、灌漑水路の整備 1,777,917ha、水源施設の改修 164,235 ha、表流水灌漑地区未整備施設の完工 86,435 ha、100 ha 未満の小規模灌漑地区の改修 109,000 ha、水管理合理化に必要な灌漑施設維持管理活動の強化 1,512,598 ha を実施することとしている。営農分野では、これらの施策実施によって手当された灌漑用水を有効に使ってコメの生産目標を達成するため、各種の営農支援プログラムを灌漑地区の受益農民が効率的に利用して灌漑稲作技術を習得することを目的とした仕組みを構築・実行することとしている。

38. 灌漑システムの水資源を有効に活用し、コメとの組み合わせにより農民にとってさらに魅力のある営農形態として、乾期を通じて灌漑水源に余裕のある場合には、水稲三期作、水稲二期作に他の食用作物栽培を組み合わせた三毛作、灌漑地区内の水田不適地を利用して造成した養魚池での淡水養魚副業経営ならびに灌漑地区隣接地でのサトウキビ栽培が想定される。三毛作に導入可能な作物は、生育期間の短い野菜などの換金作物が対象となるが、安定した収入が担保される水稲三期作と市場価格の変動幅が大きくリスクの高い三毛作のどちらを選択するかは農民の意向に委ねられる。養魚池に灌漑用水を導入するためには、灌漑法の規定に従って灌漑用水供給対象としての行政登録が必要となる。非食用目的で栽培する作物として、国のエネルギー政策においてバイオ燃料向け戦略作物に選ばれたオイルパーム・ジャトロファ・サトウキビ・キャッサバを対象として検討を行った。バイオディーゼル原料のオイルパームは湿地、ジャトロファは乾燥地に適した永年作物で、その作物特性から灌漑を必要としない。バイオエタノール原料のサトウキビ灌漑栽培を導入するには、対象灌漑地区に隣接した利用可能な耕地ならびに収穫後処理の制約条件を満たす運搬距離内に製糖工場が存在することが与件となる。キャッサバ栽培は、バイオエタノール生成技術が実用化されていないことに加え、灌漑用水を必要とせず、かつ水田の裏作に導入すると土壌物理条件を悪化させ、灌漑用水の利用効率低下の原因となることから推奨されない。

39. バタンハリ灌漑システムにおいては、竣工後 3 年が経過した 2011 年現在、バタンハリ本流の頭首工計画灌漑地区 15,271 ha のうち 5,137 ha が灌漑水田、257 ha が灌漑養魚池となり、支流 3 か所の取水堰灌漑計画地区 3,665 ha のうち 800 ha が灌漑水田、 620 ha が天水田となっている。特に、本流頭首工灌漑地区では年間を通じて灌漑用水を利用できるため、灌漑水田の 44%で水稲三期作、残り 56%で二期作が行われ、年間約 62,000 トンの籾が生産されている。平均

収量も 1 作 1 ha 当たり 4.35 トンとなり、当初灌漑計画で想定した 5 年目の目標収量雨期作 4.5 トン、乾期作 5.0 トンに近付きつつある。ダルマスルヤ県政府と DGWR との間で締結された合意書に基づいて 2014 年までに本流頭首工灌漑地区で 2,000 ha の新規開田、支流取水堰灌漑地区で 620 ha の天水田灌漑施設整備が実施されれば、バタンハリ灌漑システムの層灌漑面積は 8,557 ha となる。また、灌漑養魚池面積を 2014 年までに 700 ha へ拡大することを計画しており、これが実現した場合に、頭首工灌漑地区における 2014 年以降の灌漑水田開発可能面積は 2,970 ha が限度となる。しかし、養魚要水量が一般的な要水量に比べて過大に設定されているため、これを是正すれば将来の灌漑面積をさらに増やすことが可能である。さらに合意書においては、灌漑面積 70 ha 分の灌漑用水を利用して地元住民 13,700 人を対象にした生活用水供給を計画している。

40. ダルマスルヤ県政府が構想しているバタンハリ灌漑システムの灌漑用水を使用した小水力発電計画を検討した。その結果、バタンハリ頭首工に発電設備を付設する案およびバタンハリ灌漑システムの幹線・支線水路上に設置されている分水工・落差工・サイフォン・水路橋などの水路構造物の落差を利用する案は、いずれも施工上の難点や技術仕様を満たす発電用小型タービンをインドネシア国内で調達できないことに加え、発生電力売却先の PLN による買取り価格を基準に算出した損益分岐点 1 kW 当たり 3,000 米ドルを超過することから、事業化の対象とならないことが判明した。一方、旧ポンプ場施設利用案は、有効落差 19.0 m を確保でき、PLN 送電網との接続距離も 200 m で済む立地条件を備え、かつ水利用効率を考慮した発電通水量を 5 m^3/s と設定した場合に 420 kW の発電容量を期待できることから、灌漑用水の使用方法に関して、バタンハリ頭首工の当初計画灌漑面積に影響を及ぼさない基本シナリオと現在の未利用灌漑用水から発電用水として 5 m^3/s 分水する代替シナリオを設定し、経済性の比較検討を行ったところ、両シナリオとも旧ポンプ場施設改修経費を含む初期投資額に見合う採算性を確保できる結果が得られた。代替シナリオは発電使用水量を増やせば採算性もさらに向上するが、発電使用水量を灌漑用水として再利用する条件が付加された場合には、それに必要な経費を加算すると経済的に引き合わなくなる。基本シナリオについては、発電使用水量を担保するために作付け計画の順守とそれに対応した灌漑システムの適切な運用が必要となる。

40. 灌漑用水の最大限利用に寄与し、農家にとってより魅力のある農業経営形態を創出し、かつ国民の食料安全保障に資する方策として、以下を提案する。

- 余裕水源のある灌漑地区においては、個々の社会経済条件、自然条件、市場条件を考慮した水稲三期作ならびに三毛作を推進すること
- 個々の灌漑システムにおいて灌漑用水が適切かつ最大限に利用されているかどうかをモニタリングし、その情報をすべての関係者が共有してシステム維持管理運用業務ならびに政策形成・予算措置に適時に反映させることを可能にするツールとして DGWR の既存灌漑システムデータベースを活用し、灌漑システムの現況を正しく反映した精度の高い基礎情報を入力すること。さらに、中長期的観点から灌漑用水の持続的利用対策を検討するために、全国の流域ごとに水資源利用可能ポテンシャル、土地資源利用可能ポテンシャル、灌漑施設機能状態、灌漑用水供給状況、稲作ポテンシャルを再評価すること

Summary

Background of the Survey

1. The Government of Indonesia (GOI) has given importance on rice production increase and rice price stabilization since the founding of the country, and promoted to deal with its priority policy issues concerning development of irrigation systems and dissemination of agricultural techniques. The Government of Japan (GOJ) has cooperated with implementation of irrigation development and rehabilitation projects throughout the country along with such GOI's policy. As a result, the existing irrigation systems are regarded as useful measures which ensure stable irrigation water supply, sustainable increase in farm production and wide-ranged adaptability to climate changes.

2. In Indonesia, water resources have been mostly used for irrigation purpose. With the recent high level growth of domestic economy, however, water demand for the use by municipal, industrial, hydropower generation and fish culture sectors has been rapidly increasing. As a result, the conflict of water resources utilization between the irrigation sector and other sectors has become a serious issue. Furthermore, a more critical issue in Java Island is the conversion of productive irrigated paddy field for non-agricultural use coupled with the cancellation of irrigation water supply, but no accurate data indicating such trends are available at moment. In contrast, the conflict of land resources utilization within the agricultural sector is recognized as a regardless issue in Sumatra and Kalimantan Islands, since a considerable number of farmer, who migrated in tidal irrigation areas, have converted their low productive paddy fields to perennial crop planting areas such as oil palm and rubber with the recent rise of commodity market price.

3. In the irrigation sector, there exist many irrigation systems under the condition either with irrigation facilities already developed but paddy field not yet prepared or rain-fed paddy field available but irrigation facilities not yet developed and/or not functioning. Among others, it is considered as one of the reasons why the performance of tertiary development in the existing irrigation areas has not been doing well that farmers are passively for shouldering their legally responsible burden for tertiary development and management, because they could not have clear prospects for their farm management in the future after self-investment in tertiary development. With such background, it is required for showing farmers with preferable farm management models with higher value added potentials by utilizing irrigation water to a maximum extent.

Objectives and Implementation of Survey

4. The objectives of this survey is to investigate the possibilities through effective utilization of water resources in the existing irrigation system areas: i) producing foods including fisheries based on farming systems more attractive to farmers in combination with paddy cultivation; ii) growing bio mass crops as renewable energy sources; and iii) generating hydro electricity power: as well as to recommend outputs of these investigations to GOI. In addition, the present situation of irrigation projects implemented by Yen Loan is investigated.

5. This Final Report has been prepared based on the results of the above investigations in accordance with the Minutes of Discussion on Survey for Maximum Utilization of Irrigation Water (hereinafter referred to as "Survey") between the Japan International Cooperation Agency

(hereinafter referred to as “JICA”) and the Ministry of Public Works on behalf of the Government of Indonesia (hereinafter referred to as “MPW” and “GOI”) signed on August 26, 2011. The field survey was conducted between October 24 and Novemver 27,201. In the course of the Survey, a new national policy on rice production was announced by GOI through the Ministry of Agriculture (MOA) in January 2012 in the form of ““*Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 Juta ton Pada Tahun 2014* (Roadmap towards National Rice Surplus 10 million tons in 2014).” This new policy was adopted as one of priority subjects for the management of national macro economy by the National Development Planning Agency (BAPPENAS) in February 2012, and furthermore applied by MPW to its strategic plan in the water resources sector. Considering that this policy is closely related to the maximum utilization of irrigation water, its strategies are referred to in this Final Report.

Current Situation of Irrigation Sector

6. The total design irrigation service areas in the country increased to 8.77 million ha in 2007, an addition of about 0.46 million ha over the extent of 8.31 million ha reported in 1992. The change in the design irrigation service areas by region and type of irrigation water resource are summarized in the following table. In the surface irrigation areas, the reservoir irrigation areas of around 0.80 million ha is included, and its coverage ratio of each regional surface irrigation areas is 5.9% in Sumatra, 18.5% in Java. 6.9% in Bali and Nusa Tenggara, 1.4% in Kalimantan, 3.9% in Sulawesi and 11.1% in the whole country.

Change in Design Irrigation Service Area by Type of Irrigation Water Resources

Unit: 1,000 ha

Region	Surface Irrigation		Tidal Irrigation		Groundwater Irri.		Total	
	1992	2007	1992	2007	1992	2007	1992	2007
Sumatra	1,984	1,999	1,144	692	4	4	3,129	2,695
Java	2,169	3,305	0	0	42	68	2,211	3,373
Bali, Nusa Tenggara	416	434	0	0	79	12	495	446
Kalimantan	188	511	603	280	0	0	791	791
Sulawesi	1,005	867	521	72	26	7	1,552	946
Maluku & Papua	75	114	58	409	0	1	133	524
Indonesia	5,837	7,230	2,326	1,453	151	92	8,314	8,775

Source: FIDP and DGWR database

7. As stipulated by the Government Regulation No. 20 / 2006 on Irrigation, in accordance with the national decentralization policy, the authority and responsibility of irrigation system management are shared among the national, provincial and district/municipal governments based on the principles determined by size of irrigation system and administrative boundary as shown below.

Criteria for Sharing of Irrigation System Management Responsibility

Location	Size		
	A > 3,000 ha	3,000 ha > A > 1,000 ha	1,000 ha > A
Inter Provinces	Central	Central	Central
Inner Province	Central	Province	
Inter Districts	Central	Province	Province
Inner District	Central	Province	District

Actual management activity at central level is in charge of DGWR regional offices/
Source: Government Regulation No. 20/2006 on Irrigation

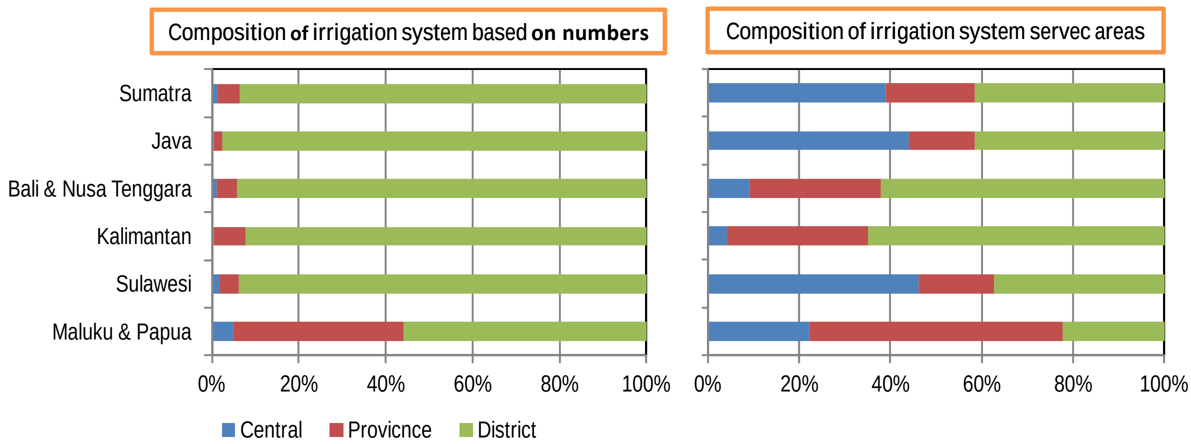
8. The total number of surface irrigation systems in Indonesia is 33,226, and the following table shows the details by design irrigation service area and management authority.

Irrigation Service Areas by Management Institution as of 2007

Region	District/Municipal Government				Provincial Government			
	Inner District/Municipal				Inter District		Inner District	
	A<100 ha		100 ha<A<1,000 ha		A<3,000 ha		1,000 ha<A<3,000 ha	
	System (nos.)	Area (ha)	System (nos.)	Area (ha)	System (nos.)	Area (ha)	System (nos.)	Area (ha)
Sumatra	1,998	107.956	2,831	715,975	55	31,726	218	358,136
Java	17,984	505,216	3,155	807,497	228	103,871	223	351,213
Bali and NT*	1,307	63,055	1,028	272,079	19	9,663	94	146,151
Kalimantan	276	17,094	1,031	307,728	0	0	106	154,408
Sulawesi	890	52,194	1,280	328,550	11	12,005	92	158,306
Maluku & Papua	21	984	70	38,082	0	0	64	97,744
Indonesia	22,476	746,499	9,395	2,469,911	313	157,265	799	1,265,958

Region	National Government						Total	
	Inter District		Inner Province		Inter Province			
	3,000 ha<A		3,000 ha<A					
	System (nos.)	Area (ha)	System (nos.)	Area (ha)	System (nos.)	Area (ha)	System (nos).	Area (ha)
Sumatra	7	141,489	56	541,049	3	93,364	5,168	1,989,695
Java	38	743,041	54	590,943	5	55,613	21,687	3,157,694
Bali and NT*	9	37,699	19	10,667	0	0	2,476	629,314
Kalimantan	1	6,000	4	15,090	0	0	1,418	500,320
Sulawesi	10	121,685	29	349,181	0	0	2,312	1,021,921
Maluku & Papua	0	0	8	55,185	0	0	165	191,995
Indonesia	65	1,049,914	170	1,652,115,	8	148,977	33,226	7,490,639

*Note: *; Nusa Tenggara, Source: DGWR database*

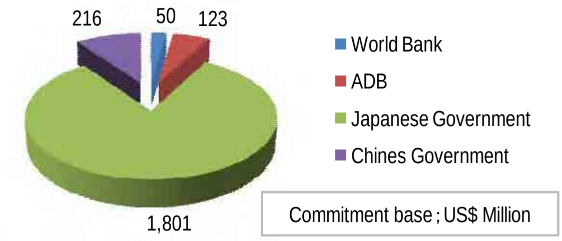


Source: DGWR Database on Irrigation Scheme

Classification of Design Irrigation Service Areas by Management Authority

9. International organizations and GOJ have contributed to financially and technically assist GOI for implementing the development of new irrigation projects and the rehabilitation of existing ones to a considerable extent. In line with the decentralization policy, the international organizations have supported to strengthen water users associations as a main body of operation and maintenance

(O&M) of the tertiary systems of irrigation schemes and to empower institutions on conservation and irrigation management. In contrast, GOJ has provided GOI with a great deal of financing for individual projects with the accumulated irrigation areas covering 1.53 million ha of completed and on-going projects till now. The donors' shares of loans for ongoing projects executed by MPW and DGWR as of November 2011 is illustrated as below.



Source: Laporan Bulanan Monitoirng Proyek-Proyek PHLN di Lingkungan Kementerian Pekerjaan Umum IBPD, ADB, IDB, JICA,China, Australia, Korea dan Perancis, October 2011, MPW

Donor's Share of Financed Amount for On-going Projects under Execution of DGWR

10. After completing irrigation development project implementation, O&M works are responsible for Indonesia, and the government institutions share O&M works for fundamental structures up to the secondary canal networks of irrigation systems according to the legal regulation, while water users associations organized by beneficiary farmers are legally responsible for implementation of O&M works for tertiary canal networks. Although, O&M activities of the irrigation systems are delegated to the central, provincial and district governments with substantial budget allocations from GOI, expenditure required for O&M works has estimated at about USD15/ha below the actual needs. O&M budget allocated needs to cover administrative costs including manpower cost and to be partly allocated for emergency reserve so that the actually allocated O&M works by each authority is usually insufficient.

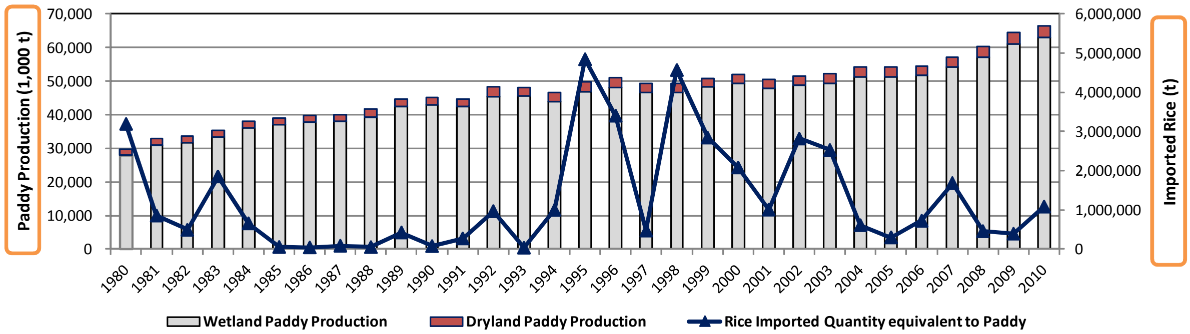
11. Main issues confronted with the irrigation sector are summarized as follows:

- Acceleration of planning followed by implementation of rehabilitation works of the existing irrigation systems, which is necessary for timely and even distribution of irrigation water;
- Urgent completion of incomplete irrigation facilities as designed;
- Preparation and undertaking of tertiary system improvement works with the use of pre-cast concrete products in order to encourage beneficial farmers to positively participate in O&M activities; and
- Drawing up and practice of effective measures for improving the functions of tertiary networks for enabling farmers to conduct on-farm level water management practices focusing on water saving and low input paddy cultivation technologies.

Role of Irrigation Sector to National Food Security

12. In the National Medium-term Development Plan (RPJMN) 2010-2014, prepared based on the actual progress during the initial three years of RPJMN 2005-2009, the production of paddy as staple food for Indonesia's people was targeted at 75.7 million tons in 2014.

13. According to the database of MOA and Statistics Indonesia, the annual total paddy production in Indonesia has been increasing since 2007 but rice is still being imported continuously for meeting the local demand. The annual imports reached around 1.5 million tons in 2011, making Indonesia the largest to second largest importer in the international rice market.



Trend of Paddy Production and Rice Import for Past 30 Years

14. Despite self-supply quantity of rice in Indonesia has increased since 2007 resulting from the expansion of dry season irrigated paddy cultivation areas owing to the implementation of irrigation development and rehabilitation projects, Indonesia has still imported rice of 0.5 million tons to one million tons every year. In response to the president's direction, government institutions concerned jointly started to draw up a strengthening plan of national food security from February 2011. Its output, "Roadmap towards National Rice Surplus 10 million tons in 2014", was reported to and approved by the cabinet meeting in January 2012. In this new rice policy, the paddy production target was modified to 79.4 million tons in 2014 as shown below.

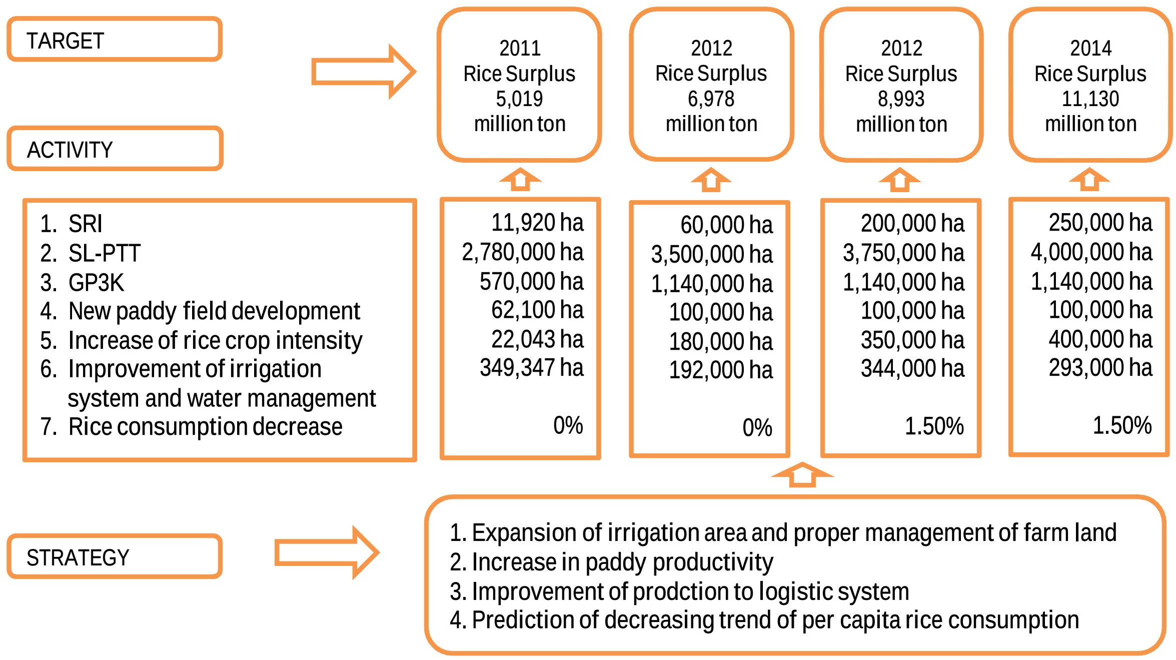
Annual Target of Rice Surplus

Year	Predicted Population (person)	Per Capita Consumption (kg/year)	Demand for Milled Rice (t)	Supply Dry paddy (t)	Milled rice (t)	Rice Surplus (t)
2010	237,556,363	139.15	33,055,968	66,469,394	37,371,255	
2011	241,095,953	139.15	33,548,502	68,596,415	38,567,136	5,018,534
2012	244,688,283	137.06	33,537,649	72,026,235	40,495,492	6,957,843
2013	248,334,138	135.01	33,526,799	75,627,547	42,520,267	8,993,467
2014	252,034,317	132.96	33,515,954	79,408,924	44,646,280	11,130,327

Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

15. The outline of strategy and action plan of the roadmap is illustrated in the following page. Focal points are the conservation of high productive paddy fields, betterment of production basis and enhancement of paddy productivity in the upstream part, the reduction of losses born from harvesting to post-harvesting and logistic stages in the midstream part, and the prediction of per capita rice consumption caused by diversification of people's tastes for food with the national economic growth in the downstream part.

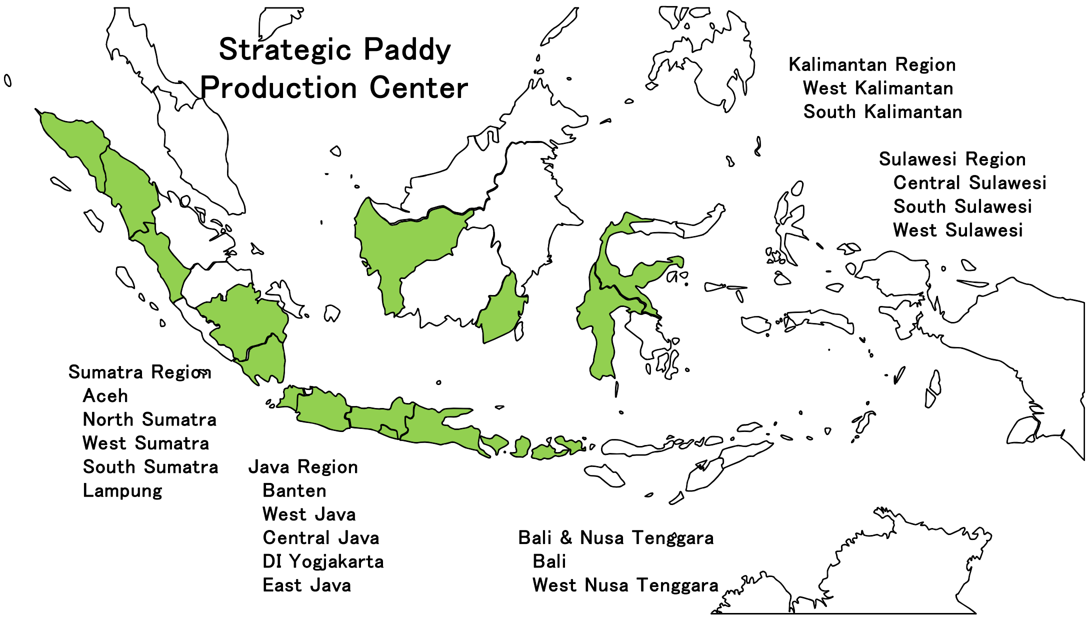
16. In order to attain the production goals laid down in the roadmap, targets of the irrigation sector for development of service areas during the four years, for completion by 2014, are set as: 1,777,917 ha of irrigation canal network improvement; 164,235 ha of water source facility rehabilitation; 96,425 ha of surface irrigation system full utilization; 109,000 ha of village irrigation improvement; and 1,512,598 ha of water resource management.



Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

Roadmap and Target Regions of the National Food Security Strategy

17. Aiming at the improvement of food crop productivity under irrigated condition, the present technical level of crop cultivation practices are to be graded up through field school for integrated crop management (*Sekolah Lapangan Pengolalaan Tanaman Terpadu*, SL-PTT) activity and promoted by corporative groups, acting as key players for crop production, into which the existing farmers group (*Kelompok Tani*) and WUA are combined. To cope with limited availability of water resources for the dry season, a full-scale extension of SRI is to be made focusing on strategic paddy production centers as shown below coupled with strengthening of cooperation between relevant sectors as well as central and rural authorizes.



Source: Rencana Strategis Kementerian Pertanian Tahun 2010-2014

Figure 3.4.2 Strategic Paddy Production Centers in Indonesia

18. In order to realize the rice surplus of 10 million tons in 2014, the paddy production is targeted to increase by 13 million tons from 66 million tons in 2010 to 79 millions in 2014. In the roadmap, the direct effect of each activity on paddy production in 2014 is expected at 10% for introduction of SRI, 58% for implementation of SL-PTT, 22% for increase of food productivity by GP3K, 1% for new paddy field development, 7% for increase of rice crop intensity and 2% for improvement of irrigation system and water management.

19. For attaining the above target level of paddy production, it is required to increase the national average paddy yield from 6.0 ton/ha in 2010 to 6.8 ton/ha in 2014. Therefore, the following attentions need to be paid to each agricultural activity:

    - As for promotion of SRI introduction activity, it is considered to put a financial aid or financing plan and a technical support plan for tertiary or quarter canal development which is necessary for farmers to acquire on-farm level water management skill;
    - Regarding implementation of SL-PTT activity, it is needed to promote, train and develop hard-working and innovative farmers as capable trainers of SL-PTT and also to focus on creation of awareness and motivation as core players among SL-PTT trainees, considering that the key factor to attain the paddy production target is their involvement in practicing the package program consisting of promotion of high quality and high yielding variety seeds, introduction of hybrid rice, switching from heavy use of chemical fertilizers to organic farming system, implementation of wide-area integrated pest management operation, and improvement of post-harvest system;
    - Concerning food productivity enhancement, it is prerequisite to combine farmers groups and WUA into corporative groups in every villages and further to renovate the prevailing group working system on the community basis towards corporative and contract based crop cultivation system;
    - In terms of new paddy field development and crop intensity increase for which irrigation water allocation is required, it is required to establish a cooperation system among officers in charge of water resource management, irrigation and agriculture of DGWR’s regional offices, provincial governments’ offices concerned and district governments’ staff under the leadership of the district head who directs paddy production administration. Through this cooperative system, it should be done to select target areas for new paddy field development and also to cope with various problems in a flexible manner in the implementation stage of cropping and irrigation water distribution plans; and

Maximum Utilization of Irrigation Water

20. In Indonesia, many existing irrigation systems are not partly or fully functioning, even though irrigation water resources are ensured. These systems are featured by some physical troubles such as deteriorated and incomplete irrigation facilities, resulting in no supply or partial supply of irrigation water required for growing crops especially paddy under irrigated condition. On the other hand, the irrigation system, where enough irrigation water resources are available and irrigation facilities are fully functioning but diverted irrigation water is partly not used due to shortage of water users, is an exceptional case. The tidal irrigation area in swamp of Sumatra,

Kalimantan and Sulawesi were reduced by half during the 15-year period between 1992 and 2007. Such fact was brought about by converting paddy fields to perennial crop fields in swamp transmigration areas where considerable immigrants had suffered from low paddy productivity of less than 1.0 ton/ha due to poor drainage condition or strong soil acidity caused by implementing excess drainage measures. As a result, they gave up paddy cultivation and then decided to participate in the small holder oil palm planting promotion program of MOA. Concerning rubber as another popular perennial crop in the country, there is rarely irrigation system where beneficiary farmers in a group intentionally converted paddy fields for rubber planting purpose, although it is found here and there in Sumatra that some individual farmers, giving up farming, planted rubber seedlings on their irrigated paddy fields before leaving from their places.

21. According to the rapid assessments on the current situation of irrigation infrastructure carried out by DGWR in 2010, performance and sustainability of the existing surface irrigation systems tended to have declined during the 11 years period between 1999 and 2010 as summarized in the following table.

Change in Irrigation Infrastructure Condition of Surface Irrigation Systems

Condition	1999		2010	
	(ha)	(%)	(ha)	(%)
Good	5,254,951	77.6	3,481,298	48.1
Minor / Moderate	1,389,938	20.5	3,043,313	42.1
Severe	126,127	1.9	705,572	9.8
Total	6,771,016		7,230,183	

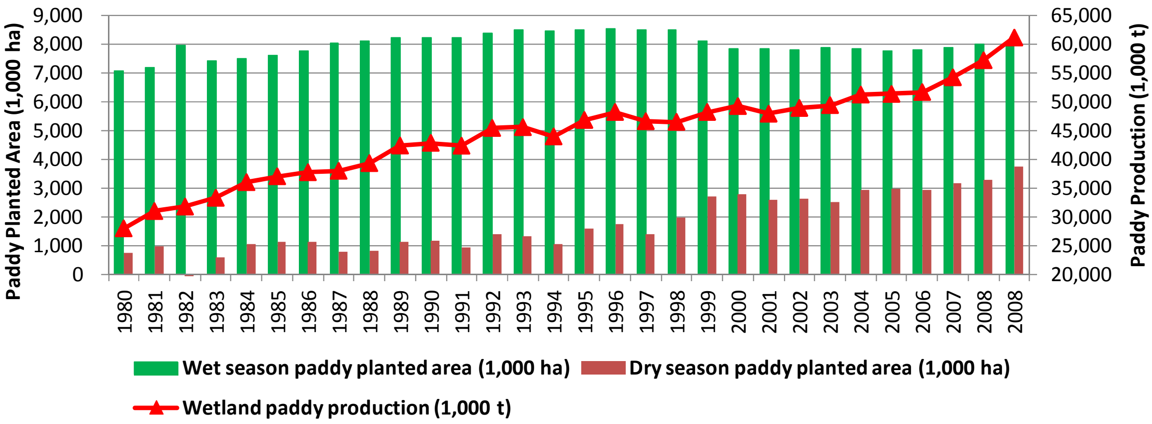
Source: MPW, 2011

22. Assuming that the difference obtained by subtracting the design irrigation service areas, based on DGWR database, from the agricultural land use and annual harvested areas of paddy field areas, based on MOA and Statistical Indonesia (BPS), seems to indicate areas of the dry season irrigated paddy cultivation areas. The cultivation area of dry season paddy has increased by 39% from 750,000 ha in 1990 to 1,050,000 ha in 2010 as shown in the following page. Such increases are greatly indebted to irrigation projects completed and then operated during this period. In the roadmap, paddy field areas in the country as of 2010 are estimated, based on the cropping intensity, at 1.75 million ha for the intensity of more than 200%, 2.16 million ha for the intensity of 150% to 200%, 1.22 million ha for 100% to 150% and 2.98 million ha for less than 100%. From this, it is presumed that double cropping of irrigated paddy is practice in 22% of the total paddy field areas in the country.

23. In compliance with such participatory approaches to the maximum utilization of irrigation water, the existing irrigation systems are to be broadly classified in the following three categories:

- Category I: Irrigation systems with the full extent of dry season irrigation areas are to target on double cropping of paddy plus cash crops and/or leguminous crops grown during the later dry season;

- Category II: Irrigation systems with partial dry season irrigation areas are to direct to irrigated paddy cropping to the maximum limit plus rain-fed cash crops and/or leguminous crops; and



Source: Database of MOA

Trend of Paddy Production and Rice Import for Past 30 Years

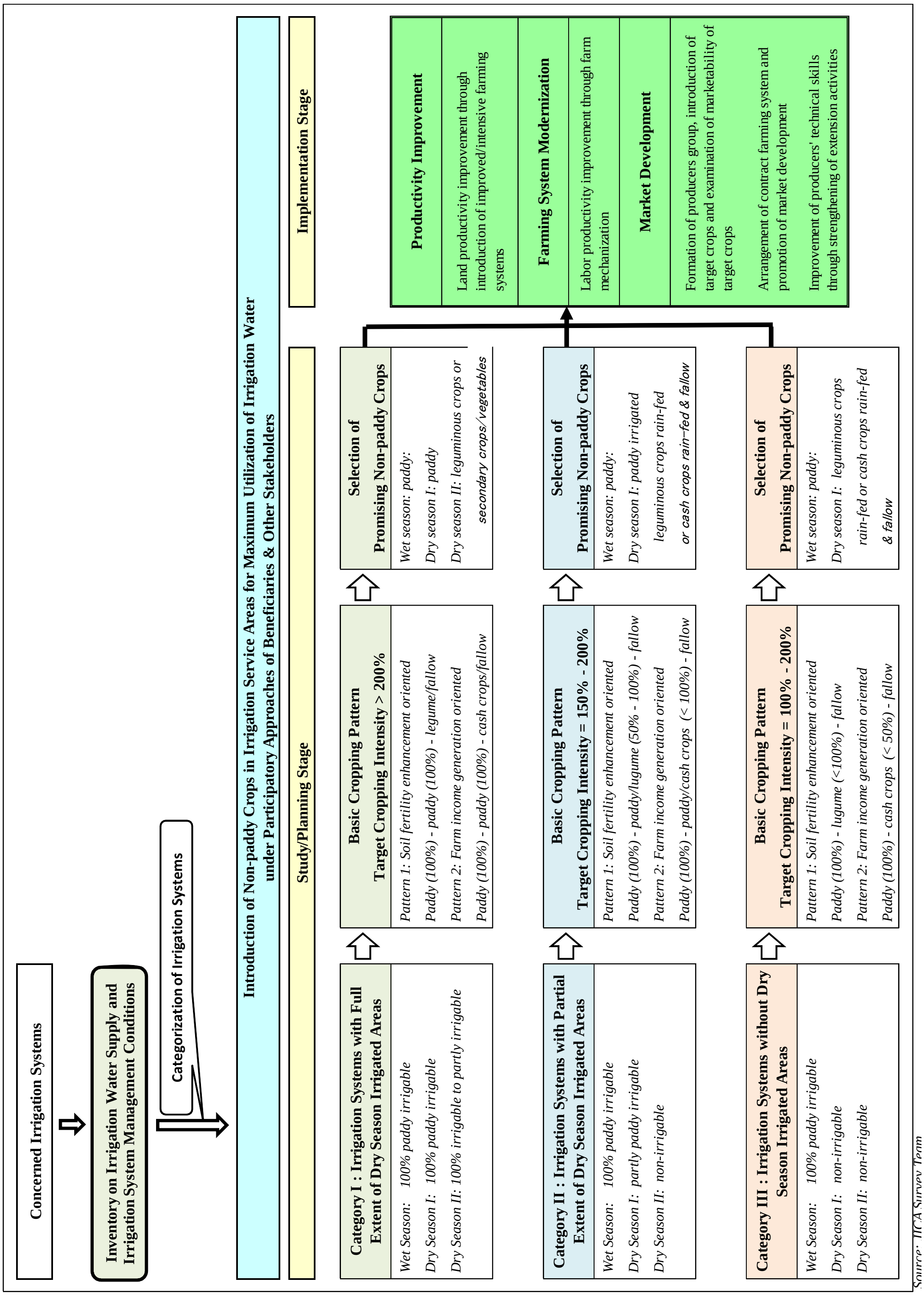
- Category III: Irrigation systems without dry season irrigation areas are to concentrate on rain-fed legumes during the dry season to a considerable extent aiming to increase productivity of wet season paddy through enhancement of soil fertility.

24. The basic agricultural approaches for each category of irrigation system are as below and its schematic approach to prepare the cropping pattern for Category I areas is illustrated in the following page:

- Category I irrigation areas: With the most emphasis on the activity No. 5, crop intensity increase, of the new rice production policy, the triple cropping system of paddy growing short-term maturity varieties during the later part of dry season should be introduced if irrigation water resources are available, contributing to the maximum utilization of irrigation water. Furthermore, additional cropping systems are to be practiced during the later part of dry season every two years such as: i) to leave paddy fields fallow in a wide area for making intermittent period without rice plants with the aim of preventing paddy field from a hotbed of harmful insects caused by year-round paddy cultivation; ii) to grow green manure crops in order to improve soil fertility; and iii) to raise cash crops for diversifying farm income sources of smallholder rice cultivation farmers;

- Category II irrigation areas: For stabilizing irrigation water resources during the dry season, the construction of water source facilities with reservoirs as well as the recovery and strengthening of water resources conservation capacity in catchment areas are most effective, but the both need to be implemented in the medium to long run. In irrigation areas where no required water for irrigated cropping during the dry season can be temporally or permanently secured, the activity No. 1, introduction of SRI, and the activity No. 6, improvement of irrigation system and water management, should be implemented with the emphasis on rehabilitation of water source facilities, round-up of surface irrigation systems with incomplete irrigation canals and structures, rehabilitation of village irrigation systems and strengthening of O&M activities of irrigation facilities required for rationalization of irrigation water management, contributing to the maximum utilization of limited irrigation water and expansion of dry season irrigated paddy cropping areas. In addition, the same farming practices adapted to the dry season cropping in Category I areas;

- Category III irrigation areas: Irrigation canal network development as one component of the activity No. 6 should be implemented as the starting point. As a result, water resources could be partly used for the dry season irrigated cropping and then the same activities adapted to the dry season cropping in Category II areas should be performed, contributing to the maximum utilization of irrigation water.



Basic Approaches for Maximum Utilization of Irrigation Water

25. Based on the study conducted by the Soil Research Institute of MOA on land suitability of overall crops grown in Indonesia, the profitability any other non-paddy crops as of 2011 is compared with irrigated paddy based on net returns and labor productivity. The results show as follows:

- Profitability per hectare and one cropping: Red onion 318>Chili 255>Cassava 250>Eggplant 107>Paddy>100>Maize 93>Groundnut>85>Sugarcane>83>Rubber 80>Long bean 71>Oil palm and Cucumber 62>Green bean 40>Soybean 36; and

-- Labor productivity per hectare and one cropping: Oil palm 299>Rubber 180>Cassava 157> Chili 150>ong bean 144>Red onion 141>Cucumber 135>Sugarcane 123>Maize 117>Grounnut 110>Paddy>100>Eggplant 98>Soybean 73>Green bean 66.

The profitability and labor productivity of perennial crops are estimated taking into account the life period such as 24 years for oil palm, 19 years for rubber and three years for sugarcane, The selection of crops largely depends on a farmer’s sense of value.

26. If year-round surplus of irrigation water is available in an irrigation area, it is possible to introduce freshwater or brackish water fish culture by supplying surplus water to a new fish pond which is developed by utilizing a small swamp or depression with poor drainage condition located in or around the irrigation area. Such practice will not reduce the existing irrigation paddy field area and in contast will contribute to the maximum utilization of irrigation water. For any fish ponds which obey the rule of the Government Regulation No. 20 / 2006 on Irrigation, irrigation water is individually supplied. As long as the introduction of fish culture is restricted to the irrigation system where surplus of irrigation water resources is available, the original design irrigation area will not be reduced. In designing the drainage canal network, it is desirable to pay attention to the proper layout for preventing the mixture of discharge from paddy field and fish pond aiming at reduction of water pollution risk, Usually, the water requirement of fish culture is set up at 6.0 L/s/ha for a freshwater fish pond and 1.2 L/s/ha for a brackish water fish pond. These water requirements are estimated based on assumptions such as culture period of 150 days with culture operations including dry-up of pond, cleaning of pond bottom and full watering to pond twice a year, water depth in pond of 1.5 m, percolation and evaporation losses at the same level as paddy field, use of aeration equipment and minimum extra water supply for freshwater fish culture, and intermittent diversion of supplemental freshwater for brackish water fish culture. The profitability of fish pond culture differs according to fish species. The double cropping of irrigated paddy is used as an index which is expressed at 100, the profitability index of fish pond culture with two harvesting times a year is estimated at 351 for tilapia, 155 for carp, 104 for catfish and 14 for gold fish. However, fish pond culture requires heavy self-investment for the construction of fish pond and the installation of necessary equipment as weli as annual high cash expenses to cover cost of fish fry, feeding materials and medicine. It also requires additional costs for securing alternative water sources for emergency relief and maintaining water quality, resulting in careful attention to control these risks. For the implementation of inland fish culture in a freshwater fish pond which is newly constructed in and around an irrigation area, it is needed to acquire the right of irrigation water use for the agencies concerned in accordance with the rule of the Government Regulation No. 20 / 2006 on Irrigation and to apply to the concerned irrigation commission for registration of irrigation water user which will be listed in the annual irrigation water distribution plan on district base.

27. Aiming to cover 5.1% of the total energy consumption in 2025 with bio-fuel, GOI in its National Energy Management Blueprint 2006-2025 has selected oil palm, jatropha, sugarcane and cassava as strategic bio mass crops. Among these, oil palm suitable for wet land and swamp as well as jatropha suitable for dry land are the perennial crop which requires no irrigation water supply even in young seedling planting stage and is recognized as raw materials for producing bio-diesel. Therefore, these two crops are not included in the objective crops for this Survey. Sugarcane and cassava can grow on both wet and dry crop fields, and can be used as raw materials for producing bio-ethanol. In Lampung Province of Sumatra, several bio-ethanol producing factories are under operation using molasses which are by-products of sugarcane processing, but they have not yet introduced a more efficient fermentation system using sugarcane juice. In Indonesia, the growth period of sugarcane can be shorten up to 12 months under irrigated condition so that, if planted on paddy field, the two-year crop rotation system with paddy can be practiced. Since its crop water requirement is smaller than that of rice plant, the dry season irrigated paddy cultivation areas can be recovered to a certain extent by allocating surplus irrigation water to paddy fields. For the maximum utilization of irrigation water, therefore, sugarcane cultivation is useful for irrigation areas with the following conditions:

- Surplus irrigation water is available at the planting time of sugarcane;
- Dry farm land exists adjacent to irrigation areas; and ;
- A sugar mill factory is operating at the transportable distance within a time limit to avoid sugar content reduction.

Cassava has a merit to grow anywhere under rain-fed condition with a wide range suitability to soils for using as not only a staple food but also a feeding and food processing raw material. With the recent increase in market demand and farm gate price, many farmers have been planting cassava as their second crop even in irrigated areas. However, harvesting works of cassava adversely affects the soil physical condition of paddy field resulting in increase in percolation loss during the irrigation period. Furthermore, commercial based production technology of producing bio-ethanol from residuals of cassava starch production has not put into practice yet. In due consideration of such demerit, cassava planting in the irrigation area is nor recommendable.

Study on Micro Hydroelectric Power Generation Plan in Batang Hari Irrigation Area

28. Paddy cultivation in the Batang Hari area started from the later part of 1970s when 4,000 mass transmigrated Javanese farm families moved out from the target reservoir area of Wonogiri dam in Central Java. The paddy cultivation areas further expanded by additional 3,000 farm families moved out from the same place by 1988. In order to supply irrigation water to about 3,000-ha rain-fed paddy fields which were allocated to the first group of migrants, one pump station was constructed along the main stream of Batang Hari River and three diversion weirs were facilitated on its three tributaries. Due to the oil shock in the beginning of 1990s, the operation of pump station was stopped resulting from the difficulty of necessary budget allocation for purchasing high-priced fuel. Aiming to cope with such condition, a plan to construct headworks on the Batang Hari River, the idea of which had been made in the 1980s, was materialized so that Yen Loan (IP-419) for engineering services to cover survey and detailed design works was provided

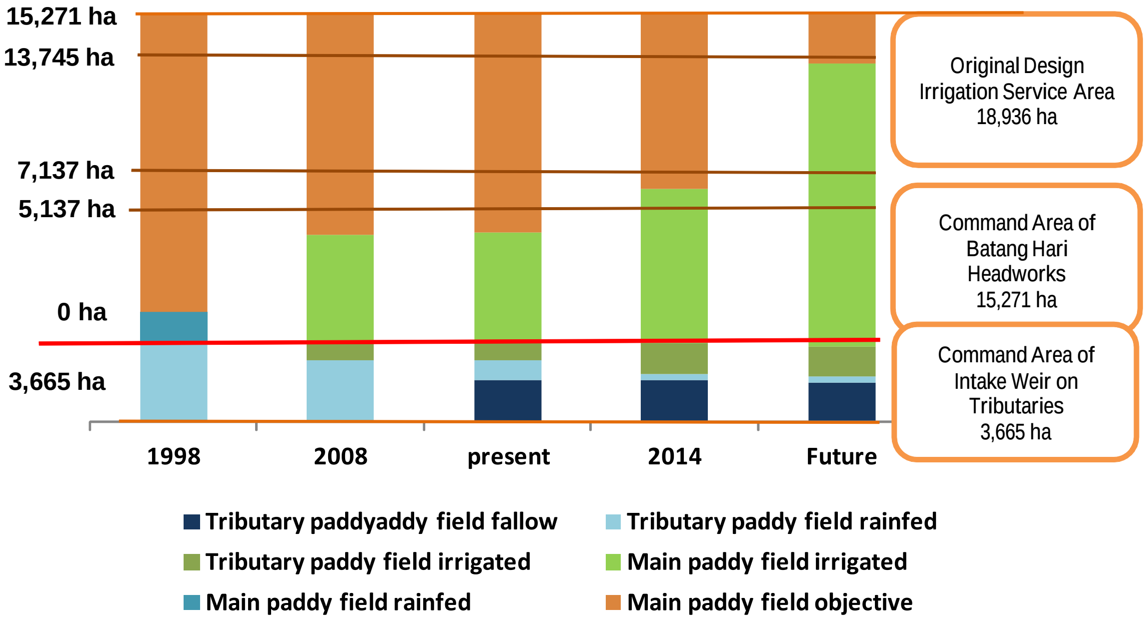
in November 1993. Based on the detailed design, the Batang Hari Irrigation Project was commenced from 1998 under Yen Loan (IP-478) signed in January 1998, aiming to construct Batang Hari Headworks as well as the upper and down reaches of the main canal. Following the construction works of main facilities, Yen Loan (IP-504) was agreed upon in July 2001 to construct the remaining part of the main canal as well as to implement land development works together with tertiary canal network construction works. Thus the irrigation water was again supplied to the Batang Hari irrigation area in May 2006 in the 12th year after the materialization of plan.

29. The original design irrigation service area of Batang Hari Irrigation System was 18,936 ha of which 15,271 ha were commanded by the newly constructed headworks on the Batang Hari River and the remaining 3,665 ha were provided with irrigation water by the existing diversion weirs on three tributaries. When the Batang Hari Irrigation Project was completed in 2006, the actual irrigated paddy field area was 5,836 ha comprising 5,036 ha commanded by the Batang Hari headworks and 800 ha commanded by the three diversion weirs on tributaries. It involves various factors in the low performance of irrigation area development as chronologically listed below:

- Firstly, insufficient disclosure or dissemination activities by the project executing agencies concerned to expected beneficiary farmers regarding the outline of Batang Hari Irrigation Project from the initial stage when the plan was materialized, triggering suspicion about the realization of irrigated farming among them;
- Secondly, delay of commencing education activities targeting local spontaneous migrants, who had less experience of paddy cultivation in their home places and moved in settlements along the upper and middle reach of the main canal, to encourage them to participate in irrigated farming; leading reduction of farmers' willingness to participation in the project;
- Thirdly, sudden rise of international rubber market price, accelerating farmers to participate in the poor smallholder rubber planting program promoted by MOA focusing on their 1-ha upland field which was allocated at the transmigrated time; and
- Fourthly, as a consequence of the above factors, slow progress of paddy filed development component which was another key component of the project to convert upland field, fallow land and rubber planted area to paddy fields, covering about 75% of the design irrigation service area of 18,936 ha.

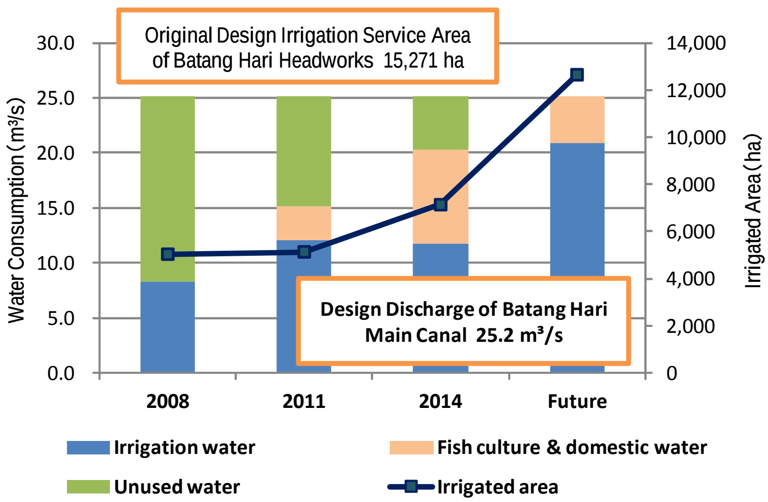
30. The economic base of Dharmasuraya District, newly founded in 2004, is the Batan Hari Irrigation System. Its total population according to the 2010 population census was 186,354. At present, 62% of the whole households of 56,000 are engaged in paddy cultivation as their main farm income sources and earn sub-income from rubber planting, while 29% is full-time rubber planting farmers. As of 2011 after three years from the project completion, the total irrigated paddy field area of Batang Hari Irrigation System has increased by 101 ha to 5,937 ha and freshwater fish culture ponds of 257 ha also receive irrigation water. Out of the total irrigated area, the Batang Hari main canal is commanding 5,137 ha by year-round irrigation water supply. As a result, the triple cropping of irrigated paddy is conducted in the net area of 2,260 ha, and the double cropping area covers the remaining 3,057 ha as llustrated in the following page. Such fact reveals that paddy cultivation farmers have realized their farm income enhancement by using

irrigation water to the maximum extent. In the tributary command area of 3,665 ha, however, only 571 ha of paddy field is under irrigated condition, 620 ha under rain-fed condition and 2,245 ha under fallow or non-agricultural use. As of 2010 in the existing paddy field under Batang Hari Irrigation System, the average paddy yield was 4.45 ton/ha, and the total paddy production was around 62,000 tons from the annual harvested area of 13,555 ha. The paddy yield level of seventh to eighth cropping since 2008 has already reached nearly to the target yield level of 4.5 ton/ha during the wet season and 5.0 ton/ha during the dry season. In some part of the command area, the average yield exceeds over 6.0 ton/ha.



Change in Irrigated Paddy Field Area in Batang Hari Irrigation System

31. Regarding the Batang Hari Headworks, the design discharge is 25.2 m^3/s and the maximum intake capacity is 30.2 m^3/s for commanding the design irrigation area of 15.271 ha. Figure 4.3.2 shows the water use condition based on the actual and expected irrigation areas. If the above target of 2014 will be realized, the potential irrigation development area after 2015 will be 2,970 ha. For the small-scale drinking water supply project, 0.12 m^3/s of irrigation water will be allocated from the Batang Hari main canal, which is equivalent to irrigation area of 70 ha and estimated following the target of unit water requirement set in the United Nations' Millennium Development Goals.. This water supply system is planned to meet

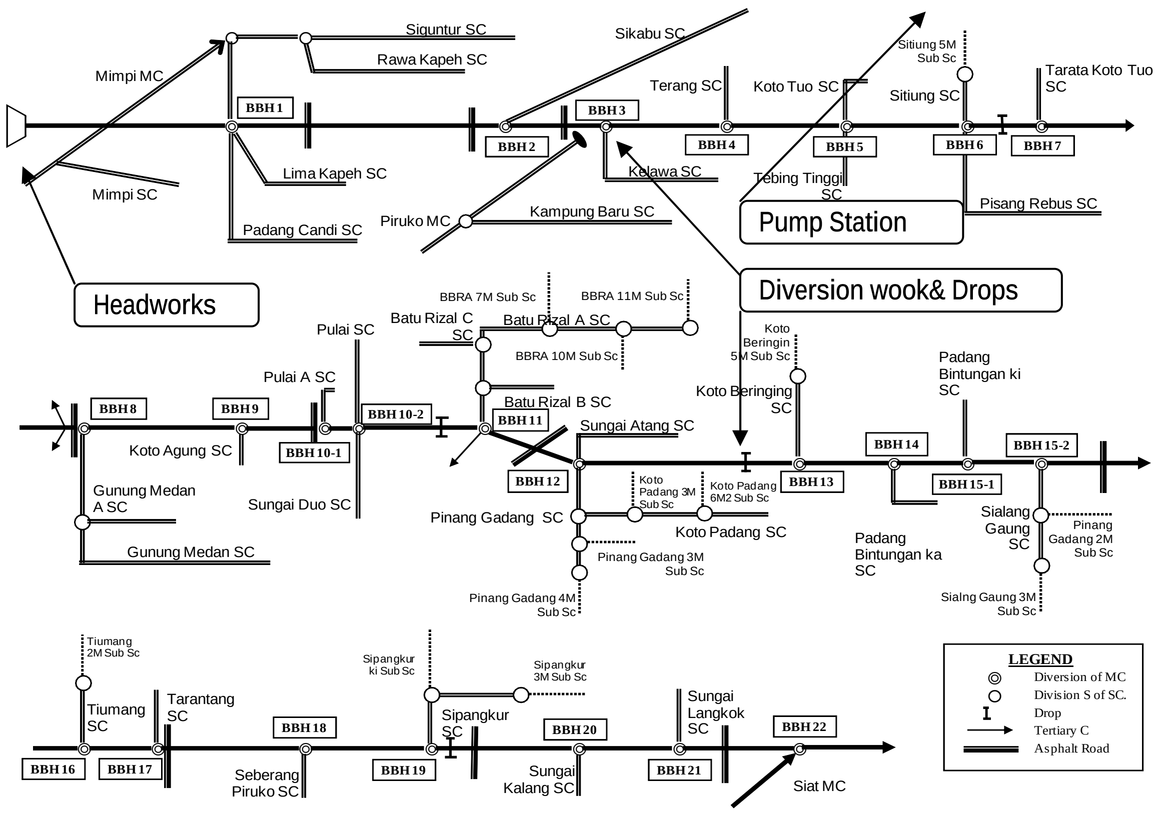


Change in Irrigation Water Allocation

the future domestic water demand in 2026 for the predicted water supply population of 13,700 in the economic activity center of Dharmasuraya District. Since freshwater fish culture water requirement in the strategic development policy is overestimated, the irrigation area could be expanded more by reducing 12.0 L/s at the present planning level to 6.0 L/s at the standard level.

32. In order to take advantage of such opportunities, primary efforts should be made to bring high potential of irrigated paddy cultivation into full play in the not yet optimized service areas of Batang Hari Irrigation System. In this regard, it is indispensable to offer various supporting services as incentives to non-paddy farmers focusing on frequent holding of SL-PTT courses coupled with technical and financial assistant menus to implement tertiary irrigation and drainage canal network development, introduction of cattle feeding in combination with compost producing facility construction, and so on. Prior to offers of such opportunities, it is needed to conduct socialization activities among stakeholders including beneficiary farmers, land holders on tertiary and quarterly canal alignment routes, elders who know the situation of communityland, and local authorities at district, sub-district and village levels aiming to achieve a consensus about land acquisition for the construction of necessary irrigation and drainage facilities.

33. A schematic diagram of the Batang Hari main irrigation system indicating locations of those drop works, diversion works and siphon as below..



Schematic Diagram of Batang Hari Irrigation System and Location of Potential Site

- This ministerial regulation aims to enhance the electricity generated by small- and medium-scale renewable energy power plants or from excess power. Also, it mandates PLN to buy renewable generated electricity up to 10 MW. This regulation offers different prices for renewable energy generated in different regions.

- Rp 656/kWh × *F* for medium voltage interconnection; and
- Rp 1,004/kWh × *F* for low voltage interconnection.

F is the incentive factor determined by regions (1.0~1.2). In Sumatra, *F* is set at 1.2. PLN may buy electricity generated from renewable energy power plant at a higher price than the “floor price” provided by this regulation. Based on this buying price, the break0even point for new investment is estimated at US%3,000:

- Power generation utilizing the head difference between the upstream and downstream of the Batang Hari headworks is also conceivable. However, there are two specific problems in case of the Batang Hari headworks. One is the necessity of a sand trap basin due to heavy sedimentation in the Batang Hari River. The other is the topography on the left bank which requires a lot of excavation
- The Batang Hari main canal has drop works and diversion works, and surplus head is dissipated to the required head in the canal section there. In case that there is sufficient head at the drop works or diversion works, the power generation is enabled by providing a penstock for another passage and generating equipment at the terminal of the penstock. However, as shown above, all drop works and diversion works have low heads of less than 2 m.
- The aqueduct is located in Sungaiduo Village, which is about 0.5 km upstream of the diversion structure BBH11 in the main canal. This idea would provide new diversion work near the existing aqueduct, and then utilize the head to the powerhouse to be constructed on the river bank beneath the aqueduct.
- As show in photograph in the following page, the current situation of the Sitiung secondary canal and the old canal for pumping. The length of the Sitiung secondary canal between the diversion structures up to its junction with the old canal for pumping is about 1.55 km. The canal has a trapezoidal section without lining, and its bottom width is 3.0~5.5m. The SEDASI pump station. Six sets of pumps and motors as well as steel pipes had been installed under the SEDASI project. Some of the steel pipes which connect the canal and building have been already removed by BWS VI for other usage. The superstructure of the building, including the roof and windows, are damaged, however, the substructure of the building seems to be still sound.

34. The old pump station ensures a gross head of 19.0 m with the distance between the station and transmission line only 200 m. Although the existing substructures of the old pump station as much as possible, it is required to rehabilitate the powerhouse and new construction of penstock. Under the basic scenario to put the priority over the water supply to the downstream irrigation area of 13,062 ha, the average surplus of irrigation water available for power generation is estimated to be 7.43 m^3/s. Under an alternative scenario to meet the water supply requirement for 7,137-ha irrigation areas, 700-ha fish ponds and small 0.12- m^3/s domestic water, it increases up to 8.19 m^3/s. The installed capacity of power plant is 420 kW. Thus, the annual energy output is computed at 2,723 MWh for the basic scenario and 3,532 MWh for the alternative scenario, respectively. Economic Internal Rate of Return (EIRR) based on preliminary design is estimated to be 10.0% at marginal level for the basic scenario and 21.1% at feasible level for the alternative

SEDACI Pumptattion

scenario.

	Irrigation Command Area downstream Diversion Works (ha)	Water Quantity for Power Generation Use(m^3/s)	Annual Power Generation (MWh)	EIRR (%)
Basic Senario	13,062	7.43	2,723	10.0%
Alternative Scenario	5,318	8.19	3,532	21.1%

35. Considering the pre-condition for taking measures to cope with the principle of DGWR, however, it is prerequisite for the alternative case to return the water to the downstream canal network of Batang Hari Irrigation System after diverting from the irrigation canal for power generation and then discharging to the river as the original irrigation water requirement is partly cut. From the economical viewpoint, however, the maximum head of pumping up by using generated power is limited to 1.5 m as long as economic viability is sustained. As no site with the height difference of less than 5.0 m between the Batang Hari River and the canal network is available, the alternative scenario is also not economical.

Conclusion and Recommendations

36. As of 2007, the total irrigable area of paddy field in Indonesia was 8.77 million ha on the basis of design irrigation service area. Out of this irrigable area, 7.23 million ha or 82% was commanded by 33,226 surface irrigation systems to which river discharges are diverted for irrigation purpose.

In these surface irrigation systems, only about 0.8 million ha is provided with regulated flows from reservoirs or ponds (*Embung*). Such situation is one of the reasons to restrict the expansion and stabilization of the dry season irrigated paddy cultivation area. In line with the decentralization policy, the management authority of irrigation systems is shared by the institutions concerned of central, provincial and district governments based on the spatial scale of irrigation systems and the administrative boundary. The responsible management authorities of irrigation systems are DGWR's regional offices at central level and the institutions concerned in charge of irrigation administration at provincial and district levels. International organizations and GOJ have contributed to financially and technically assist GOI for implementing the development of new irrigation projects and the rehabilitation of existing ones to a considerable extent. Especially, GOJ has provided GOI with a great deal of financing for individual projects with the accumulated irrigation areas covering 1.53 million ha of completed and on-going projects. After completion of irrigation development projects, O&M activities are shared by the responsible management authorities in unified manner for their responsible areas. The O&M budget allocated by each authority is usually insufficient so that irrigation areas under good functioning condition reduced by around 30% for the last 11 years.

37. Despite self-supply quantity of rice in Indonesia has increased since 2007 resulting from the expansion of dry season irrigated paddy cultivation areas owing to the implementation of irrigation development and rehabilitation projects, Indonesia has still imported rice of 0.5 million tons to one million tons every year. In response to the president's direction, government institutions concerned jointly started to draw up a strengthening plan of national food security from February 2011. Its output, "Roadmap towards National Rice Surplus 10 million tons in 2014", was reported to and approved by the cabinet meeting in January 2012. Its strategy focuses on establishment of a collaboration system among sectors with the core function made by agriculture and irrigation sectors as well as a coordination system among the institutions concerned of central, provincial and district governments. Furthermore, the action plan of this roadmap aims to intensively practice seven activities with synergistic effects if implemented in the package form. These activities were selected from sector-wise programs so far individually performed under the framework of vertical structured administration by applying the selection and concentration principle. In order to realize paddy production increase by 13 million tons for the coming four years until 2014 by increasing the average paddy yield from 6.0 ton/ha to 6.8 ton/ha, the numerical targets of irrigation activity are set up at 1,777,917 ha for improvement of irrigation networks, 164,235 ha for rehabilitation of water resources facilities, 86,435 ha for completion of surface irrigation facilities, 109,000 ha for rehabilitation of village irrigation systems with a scale of less than 100 ha and 1,512,598 ha for strengthening of irrigation facility management works necessary for water management rationalization. In agriculture sector, the focal point is to establish and practice the agricultural activity that enables beneficiary farmers to learn advanced irrigated paddy cultivation practices aiming to attain the paddy production target by effectively utilizing irrigation water secured by the above irrigation activity.

38. If surplus irrigation water is available throughout the dry season, farming systems, which are more attractive to farmers in combination with paddy cultivation, are presumed to be patterns such as: i) triple cropping of irrigated paddy; ii) double cropping of paddy plus other food crops under irrigated condition; iii) fish culture side business in fish ponds newly developed by utilizing

land resources unsuitable for paddy field; and iv) supplemental irrigated sugarcane cultivation on dry land adjacent to irrigation areas. For the first pattern, cash crops like vegetables with short growing period can be introduced, but the crop should be selected by farmers themselves according to their preference from either triple cropping of paddy with stable farm income or double cropping of paddy plus cash crop cultivation with high-risk and high-return. In order to use irrigation water for fish culture purpose, legal registration is required as an objective area of irrigation water distribution in accordance with the government regulation on irrigation. Regarding non-food crops, oil palm, jatrofa, sugarcane and cassava were selected as objective crops for the examination of growing possibilities in irrigation areas, since these crops are taken up as the strategic bio-energy resource crops in the national energy policy. The first two are perennial crops with potential for producing bio-diesel, but not suitable for the above farming systems. The pre-conditions to introduce sugarcane cultivation as a raw material of bio-ethanol for the maximum utilization purpose of irrigation water are the availability of dry farm land adjacent to irrigation areas and a sugar mill factory operating at the transportable distance within a time limit to avoid sugar content reduction. Cassava is not recommendable, considering that no bio-ethanol producing technology has been put into practice and its planting on irrigated paddy field triggers to reduce irrigation efficiency due to deterioration of soil physical condition.

As of 2011 three years after the completion of Batang Hari Irrigation Project, the irrigated paddy field and fish pond areas cover 5,137 ha and 257 ha, respectively, out of the design irrigation service area of 15,271 ha commanded by Batang Hari Headworks, and the irrigated and rain-fed paddy field areas cover 800 ha and 620 ha, respectively, out of the design area of 3,665 ha commanded by three intake weirs on tributaries of Batang Hari River. Blessed with year-round availability of irrigation water from the headworks, triple cropping of paddy is practiced in 44% of the irrigated area and double cropping covers the remaining area, producing paddy of around 62,000 tons annually. The average paddy yield has reached 4.45 tons, nearly to the target yield level of 4.5 ton/ha during the wet season and 5.0 ton/ha during the dry season. Along with the strategic development plan based on the agreement between DGWR and the Dharmasuraya District Government, it is planned to complete new paddy field development of 2,000 ha in the command area of the headworks and provision of irrigation facilities to rain-fed paddy field of 620 ha in the tributary irrigation area up to 2014. When implemented, the total irrigation area of Batang Hari Irrigation System will reach 8,557 ha. If another plan to expand fish culture ponds up to 700 ha is realized, the future extension of irrigation area will be limited 2,970 ha after 2014. Through downward modification of over-estimated unit water requirement of fish culture, further extension of irrigation area will be possible. It is also planned to allocate irrigation water equivalent to irrigation water requirement for paddy field of 70 ha to meet domestic water demand for 13,700 inhabitants living in the center of Batang Hari irrigation area.

39. With regard to the micro hydroelectric power generation ideas of the Dharmasuraya District Government, potential sites such as power generation plant attached to Batang Hari Headworks as well as drop works, diversion structures, aqueduct and siphons set on the main canal of Batang Hari Irrigation System were initially screened out due to the difficulty of construction works, the unavailability of small-size turbine pump for generation to meet technical specifications in Indonesia, and the high cost requirement exceeding the break-even point of US$3,000/kW based on the current PLN’s buying price. On the other hand, the utilization plan of the existing idle

pumping station along the Batang Hari River, with the effective head of 19.0 m and the availability of PLN grid line at a distance of 200 m, can expect the installed capacity of 420 kW by using irrigation water of 5.0 m^3/s. Taking such merits into account, the possibility of constructing micro hydroelectric power generation plant in the Batang Hari Irrigation System was preliminarily examined for two scenarios: i) a basic scenario using surplus water during the irrigation water distribution period without any effect on the original design irrigation area; and ii) an alternative scenario to directly divert irrigation water of 5.0 m^3/s for the specific use of power generation. As a result, the both scenarios will be economically viable, and, with increasing irrigation water use, the economic viability will become better. Considering the additional investment cost to cope with the condition for the reuse of discharged water for irrigation purpose, however, the alternative plan will be financially not viable. For the basic scenario, it is a prerequisite that beneficiary farmers should follow the officially decided cropping schedule in the irrigation area and the management authority should strictly control the irrigation water distribution plan according to the cropping schedule in order to ensure the surplus water for the use of power generation.

40. Aiming to contribute to the maximum utilization of irrigation water, the creation of farming system more attractive to farmers and the national food security, the following are recommended; :

- To promote triple cropping of paddy as well as double cropping of paddy ples additional cropping of other food crops considering socio-economic, natural and market conditions specified in individual irrigation systems; and
- To utilize the established database of DGWR on the existing irrigation systems as a common tool by all stakeholders aiming to support their timely planning and budgeting works based on monitoring data concerning whether irrigation water is properly and fully used in each irrigation system; to key in basic data with high accuracy and correct indication on actual condition of irrigation systems in the database; and to re-evaluate usable water resources potential, usable land resources potential, functioning condition of irrigation facilities and paddy cultivation potential in each river basin throughout the country for the purpose of drawing up a sustainable irrigation water utilization program from the medium- and long-term viewpoint.

SURVEY
FOR
MAXIMUM UTILIZATION OF IRRIGATION WATER
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

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List of Abbreviations

Abbreviations	Indonesian	English
ADB		Asian Development Bank
AF1		kW Value Adjustment factor
AF2		kWh Value Adjustment factor
APBD		District Government Budget
APBD-P		Provincial Government Budget
APBN	Anggaran Pendapatan dan Belanja Negara	National Government Budget
ASEAN		Association of South-East Asian Nations
B/C		Benefit-Cost Ratio
BAPPENAS	Bedan Perencanaan Pembangunan National	National Development Planning Agency
BLBU		Direct superior seed aid
BLP		Direct fertilizer aid
BLT		Build-Lease-Transfer
BOE		Barrel of oil equivalent
BOO		Build Own Operate
BP-PEN		National Energy Management Blueprint
BPS	Badan Pusat Statistik	Central Bureau of Statistic
BWS		Balai Wilayah Sungai
CBM		Coal Bed Methane
CBN		National seed reserve
CPO		Crude palm oil
CRF		Capital Recovery Factor
DAK	Dana Alokasi Khusus	Specific Purpose Transfer
DB		Design-Build
DBFO		Design-Build-Financial-Operate
DBL		Design-Build-Lease
DBH		Reserve sharing fund
DBO		Design-Build-Operate
DGAFI		Directorate General of Agricultural Infrastucture and Equipment
DGRD		Directorate General of Regional Development
DGWR	Directorate Jenderal Sumber Daya Air	Directorate General of Water Resources
EIA		Environmental Impct Assessment
EIRR		Economic Internal Rate of Return
EM		Electro-Mechanical
ENPV		Net Present Value
FAO		Food and Agriculture Organization of the United Nations
FIDP		The Study for Formulation of Irrigation Development Program
FIRR		Financial Internal Rate of Return
FNPV		Net Present Value
GKP	Gabah Kering Panen	Field Dry Unhusked Rice
GOI		Government of Indonesia
GOJ		Government of Japan
GP3K	Gerakan Peningkatan Produksi Pangan berbasis Korporasi	Demand based food production corporation
HM		Hydro-Mechanical

Abbreviations	Indonesian	English
HSD		High Speed Diesel
HVC		High-Value Crops
IBRD		International Bank for Reconstruction and Development
IDB		Islamic Development Bank
IEE		Initial Environmental Examination
IFAD		International Fund for Agricultural Development
Inpres	Instruksi Presiden	Presidential Instruction
IPP		Independent Power Producer
KEN		National Energy Policy
Kepmen	Keputusan Menteri	Ministerial Decree
Keppres	Keputusan Presiden	Presidential Degree
KWF		Kuwait Fund
kWh		Kilo Watt Hour
MEMR		Ministry of Energy and Mineral Resources
MOA		Ministry of Agriculture
MoU		Minutes of Understanding
MPW		Ministry of Public Works
MVC		Moderate-Value Crops
MW		Mega Watt
O&M		Operation and Maintenance
Permen	Peraturan Menteri	Ministerial Regulation
Perpres, PP		Presidential Regulation
PHLN	Pinjaman dan Hibah Luar Negeri	Foreign Loan and Grant
PLN	Perusahaan Listrik Negara	State Electricity Company
PLTP	Pembangkit Listrik Tenaga Panas Bumi	Geothermal Electricity Power Plant
PLTU	Pembangkit Listrik Tenaga Uap	Steam Elctricity Power Plant
PP	Peraturan Pemerintah	Government Regulation
PPA		Power Purchase Agreement
PPN	Pajak Pertambahan Nilai	Value Added Tax
PT PLN	Perusahaan Listrik Negara	National Electricity Company
PTT		Integrated Crop Management
PU		Public Works
SEDASI		Sungai Dareh Sitiung
SL-TTP	Sekolah Lapangan Pengolalaan Tanaman Terpadu	Field School for Intensive Crop Management
SRI		System for Rice Intensification
TWh		Tera Watt Hour
UCC		Unit Construction Cost
UKL		activities for environmental management
UPJA	Unit Pelaksana Jasa Alsintan	Farm Machinery Hiring Services Unit
UPL		activities for environmental monitoring
USDA		United States of America Department of Agriculture
UU	Undang-undang	Act/Law
UUD	Undang-Undang Dasar	Constitution
VAT		Value Added Tax
VLH		Very Low Head

Abbreviations	Indonesian	English
WUA	Perkumpulan Petani Pemakai Air (P3A)	Water User's Association

Exchange Rate

The exchange rate used in the Survey is:
US Dollar (US$) 1.00 = Indonesian Rupiah (Rp.) = Japanese Yen as of December 2011

CHAPTER 1 INTRODUCTION

1.1 Background

The Government of Indonesia (GOI) has given importance on rice production increase and rice price stabilization since the founding of the country, and promoted its priority policies concerning development of irrigation systems and dissemination of agricultural techniques. The Government of Japan (GOJ) has cooperated with implementation of irrigation development and rehabilitation projects throughout the country along with the GOI's policy. As a result, the existing irrigation systems are regarded as effective measures contributing to ensure stable irrigation water supply and increase agricultural production as well as to adapt to climate change.

In Indonesia, water resources have been mostly used for irrigation purpose. With the growth of domestic economy, however, demand for municipal, industrial, hydropower generation and fish culture have been rapidly increasing. As a result, the conflict of water resources utilization between the irrigation sector and other sectors becomes a serious issue coupled with expansion of farm land conversion for non-agricultural purpose in Java Island. In contrast, the conflict of land resources utilization within the agricultural sector is recognized as an important issue in Sumatra and Kalimantan Islands since a considerable number of farmers have preferred planting of perennial crops such as oil palm and rubber to cultivation of paddy with the recent rise of commodity market price.

In the irrigation sector, there exist many irrigation systems under the condition either with irrigation facilities already developed but paddy field not yet prepared or rain-fed paddy field available but irrigation facilities not yet developed and/or not functioning. Among others, it is considered as one of the reasons why the performance of tertiary development in the existing irrigation areas has not been doing well that farmers are passively for shouldering their legally responsible burden for tertiary development, because they could not have clear prospects for their farm management in the future after self-investment in tertiary development. With such background, it is required to show farmers with farm management models with higher value added potentials by utilizing irrigation water to a maximum extent.

1.2 Objective and Implementation Survey

The objectives of this survey is to investigate the possibilities through effective utilization of water resources in the existing irrigation system: i) producing foods including fisheries based on farming systems more attractive to farmers in combination with paddy cultivation; ii) growing bio mass crops as renewable energy sources; and iii) generating hydro electricity power: as well as to recommend outputs of these investigations to GOI. In addition, the present situation of irrigation projects implemented by Yen Loan is investigated.

This Final Report has been prepared based on the results of the above investigations in accordance with the Minutes of Discussion on Survey for Maximum Utilization of Irrigation Water (hereinafter referred to as "Survey") between the Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Public Works on behalf of the Government of Indonesia (hereinafter referred to as "MPW" and "GOI") signed on August 26, 2011. In the course of the Survey, a new national policy on rice production was announced by GOI through the Ministry of Agriculture (MOA) in January 2012 in the form of ““*Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 Juta ton Pada Tahun 2014* (Roadmap towards National Rice Surplus 10 million tons in 2014).” This new policy was adopted as one of priority subjects for the management of national macro economy by the National Development Planning Agency (BAPPENAS) in February 2012, and furthermore applied by MPW to its strategic plan in the water resources sector. Considering that this policy is closely related to the maximum utilization of irrigation water, its strategies are referred to in this Final Report.

1.3 Structure of Final Report

This Final Report consist of four main parts as follows:

- The survey results of the present situation of irrigation sector are summarized in Chapter 2 with Appendix A;
- The new policy to reserve rice surplus of 10 million tons is outlined in Chapter 3;
- The survey results of the maximum utilization of irrigation water are summarized in Chapter 4 with Appendix B focusing on food and non-food production; and
- The survey results of the surplus irrigation water use for hydro power generation in the Batang Hari Irrigation System are presented in Chapter 5.

CHAPTER 2 CURRENT SITUATION OF IRRIGATION SECTOR

2.1 Irrigated Farmland in ASEAN Countries

At present, Asia accounts for more than 70% of the world's irrigated area. Irrigated areas in Asia excluding Central Asia increased by 46.7% for the period of 23 years from 1980 to 2003 as shown in Table 2.1.1.

Table 2.1.1 Area Equipped for Irrigation and Percentage of Irrigated Area in Cultivated Land

Region	Irrigated Area (million ha)			Share in Cultivated Land (%)		
	1980	1990	2003	1980	1990	2003
World	216.5	251.7	298.7	14.9	16.5	19.6
Africa	9.3	11.1	13.4	4.8	5.4	5.7
Asia	137.4	160.5	213.1	28.9	30.5	34.0
Eastern	54.0	55.5	66.4	48.2	38.8	47.8
Southeastern	11.5	14.9	20.6	14.7	16.4	20.8
Southern	65.5	79.3	99.3	29.2	34.6	43.0
Central	-	-	11.5	-	-	35.9
Western	6.4	10.8	15.3	13.6	23.5	31.9
Latin America	12.6	15.4	18.2	9.3	10.8	11.5
Caribbean	1.1	1.3	1.3	16.9	18.8	18.1
North America	21.2	21.6	23.3	8.8	9.0	10.3
Oceania	1.7	2.1	3.0	3.5	4.0	6.1
Europe	33.2	39.7	26.4	8.9	10.8	8.9

Source: Food and Agriculture Organization of the United Nations (FAO) Resources STAT

As of 2008, the irrigated condition of farm land in eight member countries of the Association of South-East Asian Nations (ASEAN) except for Singapore and Brunei is given in Table 2.1.2.

Table 2.1.2 Irrigated Areas in ASEAN Member Countries

Unit: 1,000 ha

Country	Total Land Area	Arable Land			Irrigated Area	Irrigated Area Share (%)	
		Seasonal*	Permanent*	Total		Arable	Seasonal
Philippines	29,817	5,300	5,000	10,300	1,520	14.8	28.7
Vietnam	31,007	6,300	3,115	9,415	4,600	48.9	73.0
Cambodia	17,652	3,900	155	4,055	285	7.0	8.1
Laos	23,080	1,250	95	1,345	300	22.3	24.0
Myanmar	65,352	10,600	1,100	11,700	2,250	19.2	21.2
Thailand	51,089	15,200	3,665	18,865	6,415	34.0	42.2
Malaysia	32,855	1,800	5,785	7,585	365	4.8	20.3
Indonesia	181,157	22,000	15,100	37,100	6,722	18.1	30.6
Total	432,009	66,350	34,015	100,365	22,467	22.4	33.9

*Note: *; Seasonal indicated as temporary crop area and permanent indicated as tree crop area in the source*
Source: FAO Resources STAT

Southeast Asia is a globally important agricultural region which is a major exporter of rice, oil palm and rubber as well as forestry products. Despite trends toward urbanization as well as growth of manufacturing and services, agriculture still remains the major employer in the region except for Singapore and Brunei. Southeast Asian agriculture faces a wide array of climatic challenges. The region's monsoonal climate generates highly variable weather conditions including severe storms and extreme droughts and flooding. The overall abundance of water in Southeast Asia is tempered by the monsoonal wet-dry seasonal variation. Southeast Asia thus faces both challenges from excessive water such as flooding, erosion due to runoff and severe storms, and from water scarcity like droughts and reduced river flows. The combination of high population density and water-intensive agriculture in some areas also leads to severe localized stress on water resources and distribution systems. The productivity of the region's arable land is threatened by unsustainable agriculture practices, erosion caused by loss of forest cover, industrial pollution, and pesticides. Some of the most disruptive effects of the above climatic features may be the loss of fertile agricultural land and shifts in growing areas. Land availability is already a major problem in densely populated areas such as Java or the Mekong and Red River Deltas. Sea-level rise, flooding and erosion will all contribute to change in arable land use pattern, particularly in fertile riparian and coastal areas.

Rice is not only Southeast Asia's most important agricultural product but also the region's most important dietary staple. Although Indonesia is the world's third largest rice producer, domestic demand makes it the first to second largest world importer. The region nevertheless leads the world in rice exports, as Thailand is the world's largest rice exporter, and Vietnam the second largest. Both Laos and Cambodia are essentially rice monoculture economies. Thus, agriculture dominates the economy and employment, and rice dominates agriculture, so that a failed rice harvest could cause not merely an economic disaster, but a humanitarian one as well. The impact of specific climatic conditions on regional rice production is the single most important agricultural consideration, as rice production is water intensive, and more intermittent rainfall or delays in the monsoon may dramatically cut rice yields.

Despite the region's agricultural productivity, high rate of population growth and mismanagement of food distribution means, featured by losses in the post-harvest stage from producing to retailing sites, that food security is already a problem in many Southeast Asian countries, including the Philippines, Laos, Cambodia, Myanmar, and Indonesia. Agricultural disruptions arising from the future climatic condition far from reassuring will raise food security to the top tier of national challenges in the region. Unstable climatic condition will likely cause both absolute food shortages and sharp increases in food prices. In many cases, the most at-risk areas for climatic or environmental disruption are "rice basket" regions that feed not only the rest of their countries but others in the region as well. One of key measures for sustainable rice production in the region, therefore, is to make agricultural infrastructure more proof against risks born from climate change, especially through improvement of irrigation systems in rice cultivation areas.

2.2 Irrigation Development Performance

2.2.1 15-year Progress between 1992 and 2007

Aiming to grasp the past irrigation development performance in Indonesia, the following two comprehensive data on the respective irrigation schemes are referred to:

- Inventory survey data on existing and programmed irrigation schemes as of 1992, which were the output of "The Study for Formulation of Irrigation Development Program (FIDP) in the Republic of Indonesia" conducted by JICA in collaboration with DGWR of MPW and Bureau of Water Resources and Irrigation of the National Development and Planning Agency (BAPPENAS); and

- Database of DGWR on status of irrigation schemes recapitulated in September 2007 in line with the Government Regulation No. 20 / 2006 on Irrigation.

During this period, surface irrigation service area increased by 23.9% from 5.84 million ha to 7.23 million ha, while tidal irrigation service area in swamp reduced by 37.5% from 2.33 million ha to 1.45 million ha and groundwater irrigation service area decreased by 39.1% from 0.15 million ha to 0,09 million ha. Thus, the total irrigation service area in the country went up by 5.4% from 8.32 million ha to 8.77 million ha as shown in Table 2.2.1,

Table 2.2.1 Change in Irrigation Service Areas by Type of Irrigation Water Resources

Unit: 1,000 ha

Region	Surface Irrigation		Tidal Irrigation		Groundwater Irrigation		Total	
	1992	2007	1992	2007	1992	2007	1992	2007
Sumatra	1,984	1,999	1,144	692	4	4	3,129	2,695
Java	2,169	3,305	0	0	42	68	2,211	3,373
Bali & Nusa Tenggara	416	434	0	0	79	12	495	446
Kalimantan	188	511	603	280	0	0	791	791
Sulawesi	1,005	867	521	72	26	7	1,552	946
Maluku & Papua	75	114	58	409	0	1	133	524
Indonesia	5,837	7,230	2,326	1,453	151	92	8,314	8,775

Source: JICA study report (FIDP) and DGWR database

Focal points in relation to the above progress are as follows:

- During the same period, oil palm planting areas increased by 3.55 million ha in Sumatra and 1.53 million ha in Kalimantan, concentrating in coastal and inland swamps. One of the key players is smallholders who had initially grown wetland paddy after they migrated and then switched their tidal irrigation areas to oil palm areas with the government support programs;

- Surface irrigation service areas as of 1992 comprised 4,497,000 ha for existing 5,173 schemes and 1,339,000 ha for on-going 820 scheme areas. In addition, another 1,665 schemes covering 2,207,000 ha were proposed for implementing rehabilitation, extension or new construction works. Assuming that the on-going schemes were fully completed until 2007, the total existing scheme areas increased to 5,837,000 ha. As a result, additional irrigation areas of 1,393,000 ha were considered to be developed, corresponding to 63.1% of the proposed scheme areas; and

- Even though surface irrigation service areas expanded to considerable extent, the total coverage of 39 reservoir irrigation areas throughout the country is 799,000 ha or only 11.1% of the whole surface irrigation service areas. Its breakdown by region is 117,751 ha commanded by three reservoirs with the coverage of 5.9% in Sumatra, 610,464 ha served by 19 reservoirs sharing 18.5% in Java, 29,971 ha supported by 11 reservoirs covering 6.9% in Bali and Nusa Tenggara, 7,331 ha covered by one reservoir with the share of 1.4% in Kalimantan, and 33,562 ha guaranteed by five reservoirs covering 3.9% in Sulawesi. Such situation often triggers unavoidable risks of unstable dry season cropping of wetland paddy caused by global climate changes, as no security for year-round irrigation water supply can be expected.

2.2.2 Management Authority and Responsibilities of Irrigation Schemes

In terms of irrigation management, there exist complex problems such as:

- Vulnerability of water availability;
- Shifting value of water from a public good category which is abundant and can be utilized at no cost to become an economic and social good category;
- Increased competition in water use between irrigation and other sectors; and
- Changes in the use of irrigated lands.

Aiming to cope with the above problems, the government strategy for the water resources sector is to adopt a basin-based integrated water resources management approach, and to improve sector governance for accountability and effective service delivery of bulk water supply, irrigation, flood management and other services in different basins. In line with the Water Law of No. 7/2004 enacted based on this strategy, the new policy of irrigation management worked out in Government Regulation on Irrigation is featured as the development and management of participatory irrigation systems. Its outline is as follows:

- Development and management of irrigation are conducted through a participative approach which involves all stakeholders especially farmers in the whole process of decision making and implementation of development and management;
- Development and management of irrigation systems are conducted in an integrated manner by considering interests of the users of irrigation at the upper, middle and downstream;
- Distribution of authority and responsibility among central government, provincial governments, district/municipal governments, and farmers;
- Task redefinition of irrigation management institutions, empowerment of water users associations, and establishment of irrigation commissions as institution of coordination and communication; and
- The importance of asset management to ensure efficient financing of irrigation management.

According to current regulations, the authority and responsibility of irrigation management are shared by the national, provincial and district/municipal governments based on the principles determined by scheme size and administrative boundary as shown in Table 2.2.2.

Table 2.2.2 Criteria for Allocation of Irrigation System Management Responsibility

Location	Size of Irrigation System		
	A > 3,000 ha	3,000 ha > A > 1,000 ha	1,000 ha > A
Inter Provinces	Central	Central	Central
Inner Province	Central	Province	
Inter Districts	Central	Province	Province
Inner District	Central	Province	District

Note: Actual management activity at central level is in charge of DGWR regional offices/
Source: Government Regulation No. 20/2006 on Irrigation

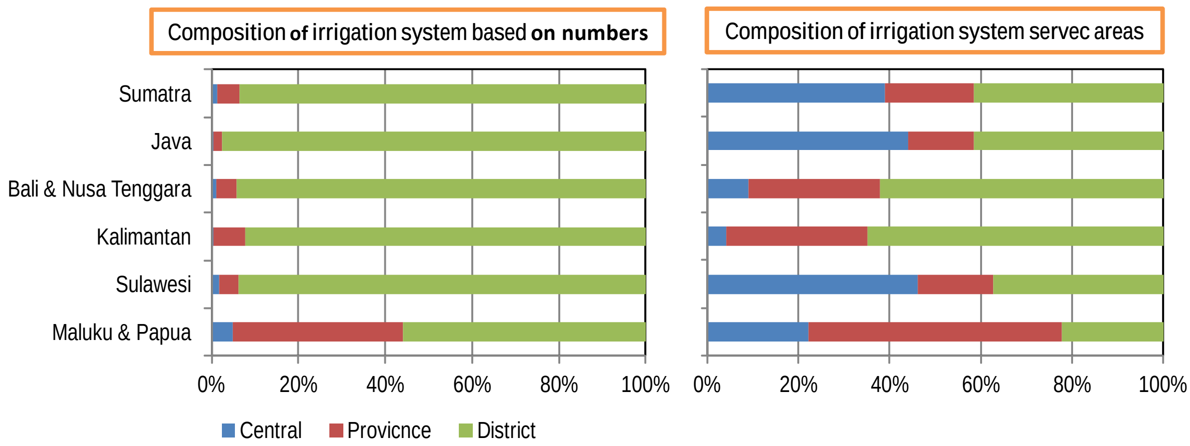
Following the above management authority and responsibility system, all surface irrigation schemes are recapitulated in 2007 on district basis. Irrigation service areas recapitulated are summarized by region as shown in Table 2.2.3 and illustrated in Figure 2.2.1. The details by province and district are compiled in Annex A1.1.1 to Annex A1.1.32 of Appendix A (Page AA-1 to AA-35).

Table 2.2.3 Irrigation Service Areas by Management Institution as of 2007

Region	District/Municipal Government				Provincial Government			
	Inner District/Municipal				Inter District		Inner District	
	A<100 ha		100 ha<A<1,000 ha		A<3,000 ha		1,000 ha<A<3,000 ha	
	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)
Sumatra	1,998	107.956	2,831	715,975	55	31,726	218	358,136
Java	17,984	505,216	3,155	807,497	228	103,871	223	351,213
Bali Nusa Tenggara	1,307	63,055	1,028	272,079	19	9,663	94	146,151
Kalimantan	276	17,094	1,031	307,728	0	0	106	154,408
Sulawesi	890	52,194	1,280	328,550	11	12,005	92	158,306
Maluku & Papua	21	984	70	38,082	0	0	64	97,744
Indonesia	22,476	746,499	9,395	2,469,911	313	157,265	799	1,265,958

Region	National Government						Total	
	Inter District		Inner Province		Inter Province			
	3,000 ha<A		3,000 ha<A					
	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)	Scheme (nos.)	Area (ha)
Sumatra	7	141,489	56	541,049	3	93,364	5,168	1,989,695
Java	38	743,041	54	590,943	5	55,613	21,687	3,157,694
Bali Nusa Tenggara	9	37,699	19	10,667	0	0	2,476	629,314
Kalimantan	1	6,000	4	15,090	0	0	1,418	500,320
Sulawesi	10	121,685	29	349,181	0	0	2,312	1,021,921
Maluku & Papua	0	0	8	55,185	0	0	165	191,995
Indonesia	65	1,049,914	170	1,652,115,	8	148,977	33,226	7,490,639

Source: DGWR database



Source: DGWR Database on Irrigation Scheme

Figure 2.2.1 Classification of Design Irrigation Service Areas by Management Authority

2.2.3 Facility Status of Irrigation Systems

An integrated database has been made by DGWR to gather together all relevant information on individual irrigation systems concerning engineering, institutional and crop production features, but the data entry works are still going on. By referring to this database, irrigation systems are classified based on the condition of irrigation facilities' function and the details are presented in Annex A1.2.1 to Annex A1.2.32 of Appendix A (Page aa-36 to AA-56). In addition, irrigation service areas as of 2005 on provincial basis were recapitulated as compiled in Annex A1.3.1 of Appendix A (Page AA-57 to AA-59). Actually, the data available in the database mostly indicate the planned and/or predicted targets set up in the planning stage, for example showing that 92% of the total design irrigation service areas throughout the country have been facilitated with tertiary canal networks. Therefore, many of data have a considerable level of discrepancy with the actual situation.

2.2.4 Maintenance Condition of Irrigation Infrastructure

Inadequate O&M financing has always been a major constraint to proper maintenance of irrigation infrastructure in Indonesia. Considering that the Water Law does not allow for water charges for smallholder irrigation, the key to maintain irrigation infrastructure in sustainable manner is to allocate timely sufficient operation and maintenance (O&M) funds from central, provincial and district government budgets. At the central level, irrigation expenditure is a joint mandate of MPW and Ministry of Agriculture (MOA). Capital investment and O&M budget for national irrigation systems are the responsibility of DGWR of MPW, while budget allocation to support on-farm and tertiary irrigation development and conversion into irrigated land is the responsibility of Directorate General of Agriculture Facilities and Infrastructure (DGAFI) of MOA,

Each level of administrative organization is responsible for O&M budget allocation for the irrigation systems under its authority. Its outline is as follows:

- At central level, DGWR funds O&M cost of its systems through the national budget (APBN) and utilize the "TP, *Tugas Pembantuan*" transfers to the provincial irrigation services for O&M implementation that often use District agencies for implementation;
- At provincial level, Water Resources/Irrigation Department (*Dinas*) funds for its systems through the provincial budget (APBD-P) originating from their own revenues (PAD) and the general purpose transfer (DAU); and
- At district level, the irrigation O&M budget comes from the district budget (APBD).

The O&M activities in all public irrigation systems are expected to be jointly executed with the Water Users Association (WUA) and its federation (WUAF) under the current irrigation regulation. At present, the above flow of O&M funds is not sufficiently coordinated, mainly caused by an overlap of functions and a lack of clarity in the responsibilities of central, provincial and district governments as well as uncertainty over the roles of water users associations. Accordingly, no statistical data on annual budget and actual expenditure for O&M of irrigation systems have been compiled so far at central, provincial and district level.

One example, which is the attachment of the MPW's Regulation No. 38/PRT/M/2006 regarding the Guideline for Implementation of Activities in Public Works" section which is under government authority and executed by de-centralization and assisting task for 2007, reveals that a total of Rp 407 billion was allocated to 23 provincial and 159 district governments in the country, comprising Rp 218 billion from the national budget source for irrigation O&M purpose and Rp 189 billion from international agencies for conservation and irrigation management empowerment purposes. Its details are compiled in Annex A1.4.1 of Appendix AA-60 to AA-67).

Another reference is the data on O&M budgets allocated to individual irrigation systems, which is collected through the monitoring survey of selected Yen Loan irrigation projects carried out under this Survey. The average annual unit amount of O&M budget per hectare is as follows:

- In 2007, the average annual unit amount of O&M budget allocated to three irrigation systems with the total design irrigation service areas of 48,699 ha is Rp 152,000/ha;
- In 2008, the average annual unit amount allocated to four systems with the total areas of 62,449 ha is Rp 218,000/ha;
- In 2009, the average annual unit amount allocated to four systems with the total areas of 59,774 ha is Rp 203,000/ha;
- In 2010, the average annual unit amount allocated to 12 systems with the total areas of 179,230 ha is Rp 216,000/ha;
- In 2011, the average annual unit amount allocated to eight systems with the total areas of 131,515 ha is Rp 153,000/ha; and
- The overall average annual unit amount of O&M budget allocated for the period of 2007 to 2011 is Rp 187,000/ha, ranging from Rp. 24,000/ha to Rp 575,000/ha.

2.2.5 Investment for Irrigation Development

(1) Budgeting System for Investment

Rehabilitation and new development of irrigation systems in national basins are funded and executed through the APBN budget of MPW. Provincial and district governments are allowed to invest in rehabilitation of irrigation systems under their management responsibility by utilizing budget sources, a major part of which is from Special Purpose Transfer (DAK) transferred from the central to the regions..

Government expenditure on irrigation has been quite unstable for the period of 2000 to 2009. The total budget allocated to irrigation sector at all levels fluctuated between Rp 6,000 billion and Rp 9,500 billion during this decade. The share of budget allocated to the irrigation sector by provincial and district governments grew 29% to 38%.

(2) Completed Foreign Loan Projects

The Ministry of Public Works has utilized foreign loans to considerable extent for the purpose of implementing infrastructure development projects in its jurisdiction sectors of water resources, highway and human settlements. Main financial sources which provide loans for water resources and irrigation development purposes are the World Bank (WB), Asian Development Bank (ADB) and the Government of Japan (GOJ). The total loan amount on commitment basis for projects completed by 2010 under the execution of DGWR is around US$3.117 billion for 26 projects financed by the World Bank group, US$777 million for 10 out of 26 completed projects financed by ADB, and around Yen 488 billion for 96 projects by GOJ as summarized in Table 2.2.4 and illustrated in Figure 2.2.2. The individual projects are listed up in Annex A1.5.1 to Annex A1.5.4 of Appendix A (Page AA-68 to

AA-74).

Table 2.2.4 Breakdown Loan Amount for DGWR Handled Projects by Decade

Donor	Unit	1970s		1980s		1990s		2000s		Total	
		nos.	Amount	nos.	Amount	nos.	Amount	nos.	Amount	nos.	Amount
WB	US$ Million	10	449.6	14	2,317.4	2	350.0	-	-	26	3,117.0
ADB	US$ Million	-	-	3	301.3	7	475.7	-	-	10	777.0
GOJ	Yen Billion	22	61.7	34	151.1	38	248.4	2	26,3	96	487.5

Source: WB, ADB, JICA

In terms of spatial performance concerning irrigation sub-sectors, a total of 45 Yen Loan projects were completed until the 2000's with design irrigation service areas of about 1.40 million ha in total. This command area is corresponding to about one-fifth of the existing surface irrigation areas in the country.

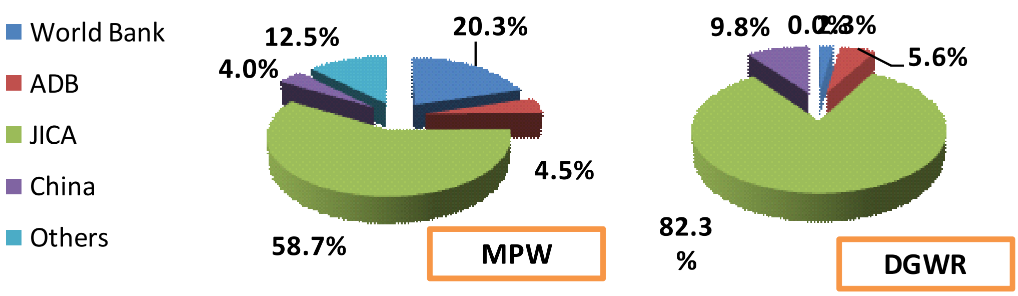
(3) On-going Foreign Loan Projects

As of October 2011, the total foreign loan amounts for 41 on-going projects handled by MPW are US$5.21 billion, around 60% of which is financed by JICA as shown in Table 2.2.5 and Figure 2.2.2. The list of on-going foreign loan projects is given as Annex A1.6.1 of Appendix A (page AA-75). The numerical breakdown is 17 projects managed by DGWR, eight by Directorate General of Road and 16 by Directorate General of Human Settlement. The 17 water resources sector projects include six irrigation projects and two river basin development projects with an irrigation component.

Table 2.2.5 Current Status of Foreign Loan Amount by Donor

Donor	**Amount (US$1,000)**	**Share (%)**	Donor	**Amount (US$1,000)**	**Share (%)**
IBRD	1,090,433	20.93	Japan	3,151,208	60.48
ADB	242,240	4.65	Australia	305,955	5.85
IDB	83,000	1.59	China	215,616	4.14
			Korea	74,000	1.42
Sub-total	1,415,673	27.17	France	48,935	0.94
Total	5,210,487		Sub-total	3,794,814	72.83

Source: Laporan Bulanan, MPW



Source: Laporan Bulanan Monitoirng Proyek-Proyek PHLN di Lingkungan Kementerian Pekerjaan Umum IBPD, ADB, IDB, JICA,China, Australia, Korea dan Perancis, October 2011, MPW

Figure 2.2.2 Donor's Share of Financed Amount for On-going Projects under Execution of DGWR

Out of the total loan amounts for on-going Yen Loan projects amounting Yen 253.0 billion (equivalent to US$3,151 million) on commitment base, 58.0% is allocated to water resources sector, 25.9% to highway sector and 16.1% to human settlement sector. Overall disbursement of the total loan amounts is 54.8% as of October 2011, while that for on-going projects in water resource sector is 63.0%.

Salient features of major completed and on-going projects financed by Yen Loan are compiled in Annex A1.7.1 of Appendix A Page AA-76 to AA-77).

2.3 Irrigation Development Policies for 2010-2014

2.3.1 Policy Direction

In due consideration of the abovementioned challenges for irrigation development and management, the policy direction of irrigation sector focuses on the followings:

- To establish new irrigation areas by prioritizing areas outside of Java Island and to improve the function of the irrigation network, especially in the area where the availability of water is assured and the farmers are ready to manage the land;
- To rehabilitate damaged irrigation networks, especially in high productive areas;;
- To optimize irrigation services through the operation and maintenance of irrigation networks;
- To increase participation of farmers in the operation and maintenance activities through the out-contracting system;
- To improve the efficiency of water utilization through water-saving agricultural technologies such as the System of Rice Intensification (SRI), water re-use, lining irrigation canals to reduce water leaks, maintenance of the function of agricultural land, and support to local governments in improving the reliability of irrigation networks through a provision of DAK.

2.3.2 Water Resources Availability

According to the analysis of availability and demand balance through dry season made by the Sub-Directorate of Hydrology, DGWR, Java, Bali and Nusa Tenggara regions have experienced deficiency due to high demand and limited water resources as shown in Table 2.3.1.

Table 2.3.1 Water Balance during Dry Season in 2003 and 2020

Region	Water Availability (Billion m^3)	2003		2020	
		Water Demand (Billion m^3)	Balance	Water Demand (Billion m^3)	Balance
Sumatra	96.2	11.6	Surplus	13.3	Surplus
Java and Bali	25,3	38.4	Deficit	44.1	Deficit
Nusa Tenggara	4.2	4.3	Deficit	4.7	Deficit
Kalimantan	16.7	2.9	Surplus	3.5	Surplus
Sulawesi	14.4	9.0	Surplus	9.7	Surplus
Maluku	12.4	0.1	Surplus	0.1	Surplus
Papua	163.6	0.1	Surplus	0.2	Surplus

Source: Sub-Directorate of Hydrology, DGWR

2.3.3 Strategic Plan

The strategic plan of irrigation sector in line with the above policy direction under the National Medium-term Development Plan (RPJMN) 2010-2014 targets on the following items for surface irrigation system:

- Implementation of operation and maintenance of irrigation networks in an optimal manner by preparation of gradually sufficient O&M, covering 2,341,363 ha; ;
- Rehabilitation of infrastructure damaged and suffering from functional degradation covering 1,342,870 ha; and
- Finalization of irrigation networks development that has not been in full development status and development of new irrigation selectively outside of Java in the potential area, choosing 500,000 ha from the potential area of 592,335 ha.

The spatial distribution of target areas is as shown in Table 2.3.2.

Table 2.3.2 Strategic Plan Target of Irrigation Sector for 2010-2014

Unit: ha

Region	Potential Area for Development	Rehabilitation of Infrastructure	Implementation of O&M	Total
Sumatra	205,442	248,168	610,144	1,063,754
Java	4,142	845,955	1,185,174	2,035,271
Bali and Nusa Tenggara	78,102	62,320	138,366	278,788
Kalimantan	87,501	19,126	26,562	133,189
Sulawesi	160,372	155,186	330,966	646,524
Maluku & Papua	56,776	12,115	50,151	119,042
Indonesia	592,335	1,342,870	2,341,363	4,276,568

Source: DGWR

2.3.4 Regional Irrigation Development Strategy

(1) Sumatra

Strategic issues, development strategies and contribution targets to rice production increase in Sumatra are itemized as shown in Table 2.3.3.

Table 2.3.3 Strategic Issues and Irrigation Development Strategy for Sumatra

Strategic Issue	Development Strategy
• Decreasing surplus of rice production resulting in less important supply source to meet the deficit of rice in Java region • Existence of uncompleted irrigation system and urgent rehabilitation works	• Effective exploitation of remaining irrigation development potential • Maintenance and upgrading of productivity of existing irrigation system • Promotion of dam irrigation project

Source; JICA Survey Team

(2) Java

Strategic issues, development strategies and contribution targets to rice production increase in Sumatra are listed up as shown in Table 2.3.4.

Table 2.3.4 Strategic Issues and Irrigation Development Strategy for Java.

Strategic Issue	Development Strategy
• Production of more than half of national rice supply, but insufficient for meeting rice demand in Java region • Conflict on water and land resources use between agriculture and non-agriculture sectors causing limitation to create new irrigation water source and continuous conversion of high productive irrigated paddy field for non-agricultural purpose	• Rehabilitation and upgrading of existing irrigation systems to maintain present high crop productivity • Improvement and modernization of large scale irrigation systems served from dam reservoirs

Source; JICA Survey Team

(3) Bali and Nusa Tenggara

Strategic issues, development strategies and contribution targets to rice production increase in Bali and Nusa Tenggara are itemized as shown in Table 2.3.5.

Table 2.3.5 Strategic Issues and Irrigation Development Strategy for Bali and Nusa Tenggara.

Strategic Issue	Development Strategy
• Imbalance between limited land and water resources as well as high density population area in Bali, and also limited water resources in Nusa Tenggara, both causing continuous deficit in rice supply • High ratio of people below poverty line	• Upgrading/modernization of existing irrigation systems to increase rice self-sufficiency rate • Promotion of dam irrigation project to utilize limited water resources

Source; JICA Survey Team

(4) Kalimantan

Strategic issues, development strategies and contribution targets to rice production increase in Kalimantan are itemized as shown in Table 2.3.6.

Table 2.3.6 Strategic Issues and Irrigation Development Strategy for Kalimantan

Strategic Issue	Development Strategy
• Rich land and water resources, but not yet sufficiently developed, resulting in fluctuation of staple food production • High level degradation of forest and land resources causing serious impact on natural eco-system, lost of biological diversification and high risk of flood damage	• Development of small and medium scale irrigation, and upgrading and modernization of existing irrigation systems to ensure rice supply source to the neighboring Bali and Nusa Tenggara regions • Strengthening of control and law enforcement to preserve forest resources and improve watershed management system

Source; JICA Survey Team

(5) Sulawesi

Strategic issues, development strategies and contribution targets to rice production increase in Sulawesi are itemized as shown in Table 2.3.7.

Table 2.3.7 Strategic Issues and Irrigation Development Strategy for Sulawesi

Strategic Issue	Development Strategy
• Increasing important position as rice supply source for deficit regions of Java and Maluku/Papua • Less development activities to utilize surplus water resources resulting in many paddy field left under rain-fed condition	• Sustainable maintenance of rice supply position to eastern part of the country • Acceleration of remaining irrigation development potential by promoting implementation of dam irrigation schemes as well as rehabilitation and upgrading of existing irrigation schemes

Source; JICA Survey Team

(6) Maluku and Papua

Strategic issues, development strategies and contribution targets to rice production increase in Maluku and Papua are itemized as shown in Table 2.3.8.

Table 2.3.8 Strategic Issues and Irrigation Development Strategy for Maluku and Papua

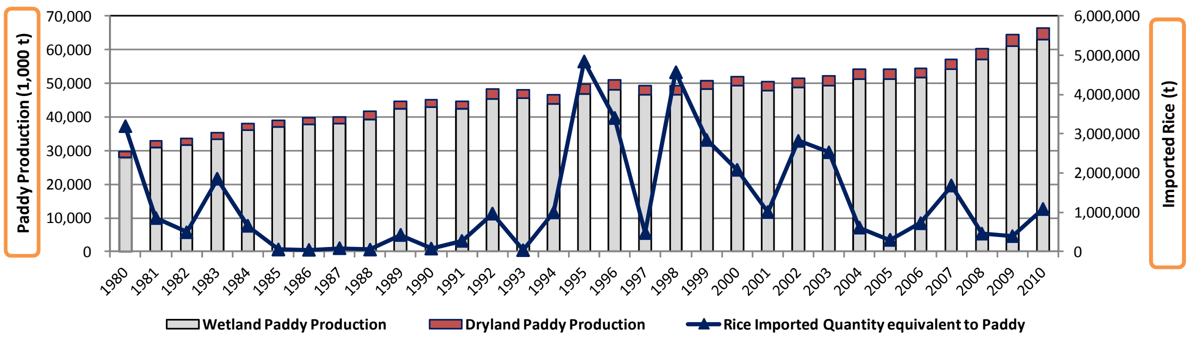
Strategic Issue	Development Strategy
• Less investment in irrigation development up to date causing low land productivity and continuous supplement of rice from Sulawesi region • Highest poverty rate of rural people in the country	• Promotion of small and medium scale irrigation development • Specific attention to tidal irrigation schemes in swamp areas

Source; JICA Survey Team

CHAPTER 3 ROLE OF IRRIGATION SECTOR TO NATIONAL FOOD SECURITY

3.1 Historical Trend of Paddy Production and Supply

During the past 30 years between 1980 and 2009, the annual total paddy production in Indonesia increased by 33.12 million tons from 27.99 million tons to 61.11 million tons, but a certain quantity of rice has been continuously imported from other countries every year, according to databases of the Statistics Indonesia (BPS) and MOA, as shown in Figure 3.1.1. Since 1994, however, the production level has been lower than the self-sufficiency level and therefore, a certain quantity of rice has been imported every year.



Source: Database of BPS and MOA

Figure 3.1.1 Historical Trend of Paddy Production and Rice Import from 1980 to 2010

The regional trend of the annual paddy harvested area and production on wet paddy fields for the last 30 years is given in Table 3.1.1.

Table 3.1.1 Past 30-year Trend of Paddy Production and Import in Indonesia

Region	1979	1984	1989	1994	1999	2004	2009
Annual Harvested Area of Paddy on Wet Paddy Fields (ha)							
Sumatra	1,592,171	1,878,832	2,123,970	2,362,087	2,699,445	2,856,001	3,067,884
Java	4,410,505	4,861,556	5,098,892	4,830,643	5,403,429	5,356,286	5,716,087
Bali & Nusa Tenggara	407,529	454,905	490,689	488,438	552,089	538,658	593,285
Kalimantan	569,637	570,587	640,247	723,003	887,213	874,104	1,002,087
Sulawesi	693,726	778,910	991,145	1,056,467	1,216,584	837,165	1,355,178
Maluku & Papua	1,550	2,335	14,378	18,280	34,451	37,258	62,883
Indonesia	7,675,118	8,547,125	9,359,321	9,478,918	10,793,211	10,499,472	11,797,404
Annual Paddy Production on Wet Paddy Fields (t)							
Sumatra	4,770,254	6,621,039	8,208,208	9,526,745	10,957,594	11,924,810	13,971,877
Java	4,770,254	22,961,300	26,171,666	25,658,851	26,914,532	28,534,779	33,477,733
Bali & Nusa Tenggara	1,315,870	1,852,263	2,154,586	2,212,520	2,500,381	2,545,378	2,995,206
Kalimantan	1,274,808	1,452,584	1,697,752	2,017,038	2,628,038	2,982,418	3,797,470
Sulawesi	1,999,797	3,024,439	4,060,908	4,451,071	5,099,102	5,093,319	6,678,959
Maluku & Papua	2,947	5,684	37,752	51,495	101,489	128,729	249,978
Indonesia	29,936,625	35,917,309	42,330,872	43,917,720	48,201,136	51,209,433	61,171,223
Yield of Dry Paddy (t/ha)							
Sumatra	3.00	3.52	3.86	4.03	4.06	4.18	4.45
Java	4,66	4.72	5.13	5.31	4.98	5.33	5.86
Bali & Nusa Tenggara	3.23	4.97	4.38	4.53	4.53	4.73	5.05
Kalimantan	2.24	2.55	2.66	2.79	2.96	3.41	3.79
Sulawesi	2.88	3.88	4.10	4.21	4.19	6.08	4.93
Maluku & Papua	1.90	2.43	2.63	2.82	2.95	3.46	3.98
Indonesia	3.90	4.20	4.52	4.63	4.47	4.88	5.19

Reference: Database of MOA

3.2 Historical Trend of Irrigated Areas

During the same period, the total area of wet paddy fields increased from 7.06 million ha to 8.06 million ha. Assuming that the ratio between the total wet paddy fields and the total annual harvested area on wet paddy fields is the dry season paddy cultivation area, this difference can be simply considered as wet paddy fields where irrigation water is supplied during the dry season. With the progress of irrigation development, therefore, the wet paddy fields under actually irrigated condition during the dry season increased by 2.97 million ha from 0.77 million ha in 1980 to 3.74 million ha in 2009.

The regional trend of the total wet paddy fields and irrigated paddy fields during the 2000s is given in Table 3.2.1.

Table 3.2.1 Regional Trend of Wetland Paddy Field Area for 2000s

Region	2000 (ha)		2004 (ha)		2009 (ha)	
	Total	Irrigated	Total	Irrigated	Total	Irrigated
Sumatra	2,112,239	1,060,150	2,209,035	1,042,950	2,346,503	1,108.688
Java	3,344,391	2,583,528	3,293,029	2,503,212	3,251,060	2,487,708
Bali and Nusa Tenggara	397,846	335,927	413,595	339,312	449,800	374,982
Kalimantan	868,437	227,924	964,450	187,285	1,025,223	229,680
Sulawesi	864.436	661,228	901,463	621,751	932,327	648,243
Maluku & Papua	61,008	38,988	62,720	40,428	56,874	49,521
Indonesia	7,848,347	4,908,765	7,844,292	4,734,938	8,081,787	4,898,822

Reference: BPS

3.3 Contribution Factors to Increase in Paddy Production

Regarding paddy cultivation under irrigated condition in Indonesia during the last 30 years, the annual harvested area increased by 53.7%, and the annual production went up by 104.3%. It is considered that the main factors contributing to such increase are the extension of irrigation water supply system as well as the improvement of farming practices. Impacts from these two main factors during the 2000s period are qualitatively evaluated for each region as shown in Table 3.3.1.

Table 3.3.1 Impacts of Main Factors on Contribution to Irrigated Paddy Production Increase

Region	Irrigation Water Supply System		Farming Practices	
	Irrigation Area Extension	Water Supply for Dry Season	Paddy Field Development	Farming System Improvement
Sumatra	◎	◎	○	△
Java	◎	◎	×	○
Bali & Nusa Tenggara	△	×	○	○
Kalimantan	◎	◎	○	◎
Sulawesi	△	◎	△	○
Maluku & Papua	×	◎	×	◎

Note: ◎; High impact>20%, ○; Medium impact=10 -20%, △; Low impact=0 – 10%, ×; No impact<0%
Source: JICA Survey Team

In the above, impacts of the respective factors are evaluated in the following manners:

- Irrigation area extension is evaluated based on increase in design irrigation service area, which is calculated by dividing increased design irrigation areas during the period of 2000 to 2009 by the design irrigation area as of 2000;

- Water supply for dry season is evaluated based on the difference between wetland paddy field area and annual harvested areas of wetland paddy, which is calculated by dividing increased dry season harvested areas during the period of 2000 to 2009 by the dry season harvested area in 2000;
- Paddy field development is evaluated by recognizing extension of wetland paddy field area, which is calculated by dividing increased wetland paddy field areas during the period of 2000 to 2009 by the wetland paddy field area in 2000; and
- Farming system improvement is evaluated based on increase in wetland paddy yield attributable to promotion of package programs comprising of the introduction of new rice varieties, improvement of seed and fertilizer subsidy systems and enhancement of capacity development activities in addition to the improvement of water supply and management, which is calculated by dividing increased wetland paddy yield during the period of 2000 to 2009 with the wetland paddy yield in 2000.

3.4 New Evolution of National Food Security Policy

3.4.1 Salient Features of Food Security

In Indonesia, rice is a highly strategic food commodity and tends to be the political commodities. The availability of rice is always monitored and observed by all levels of society from the grassroots level to the highest level among the government and legislature.

Rice demand continues to increase along with population growth. On the other hand, the existing climate changes which become more extreme due to global warming impact on the disruption of rice production process. In the future, it is believed that the world rice market will become more limited. Therefore, Indonesia should be self-sufficient in rice as well as should have enough rice reserves so that food security and food self-sufficiency will not be disturbed.

Another point resulting from rice becoming a very important commodity in Indonesia is that rice is still the major contributor to inflation and therefore, the price of rice should be “controlled”. This point also leads to the fact that the availability of rice is very important because the annual per capita rice consumption in Indonesia is still at a very high level in the world resulting to 95% of Indonesian people living on rice and spending 15% of their expenses on average for rice. In the rice production side, 83.7% of 17.8 million farm households in the country are engaged in paddy farming, according to Agriculture Census 2003 and Farm Data Collection of BPS 2009.

3.4.2 Drawing-up of New Rice Reserve Policy

Considering such background, the president gave nine directives related to maintaining food security in the plenary cabinet meeting of January 6, 2011 as follows:

- To conduct continuously market operation aiming to control prices of certain commodities especially for rice;

- To manage special fiscal policies for food trade, both imports and exports;
- To make sure that rice supply can meet national demand;
- To ensure that the rice reserves and stocks are at the strong hands of the government to prevent speculation;
- To increase domestic rice production and productivity;
- To encourage local and family food sustainability movement;
- To prevent food smuggling;
- To prepare the strong/accurate forecast or calculation of food prediction; and
- To ensure the availability of new policy or regulation on agricultural farm security.

In the cabinet meeting of February 22, 2011, the president instructed that “rice surplus” is the priority program aiming to change Indonesia from rice self-sufficiency to rice surplus in the next five to ten years, and to achieve the minimum rice surplus of 10 million ton per year in 2015. This target schedule was brought forward from 2015 to 2014 in the cabinet meeting of September 6, 2011. In line with these presidential directives, drawing-up of a program was commenced with principles focusing on:

- Opening of new farms by utilizing former fallow land;
- Development of food estate by core plasma pattern;
- Appropriate and accurate seeds and fertilizers development/preparation;
- Improvement and development of irrigation facilities;
- Improvement in the application of specific location technology package by counseling; and
- Research development and technology development in rice cultivation.

3.4.3 Outline of Roadmap for Rice Reserve 10 Million Ton Program

(1) Challenging Issues, Problems and Opportunities for Improvement of Rice Production

The program was drawn up by the highly ranked staff of relevant line ministries and submitted to the cabinet in December 2011. After the approval in the cabinet meeting, this program was issued by MOA on January 11, 2012 as “*Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 Juta ton Pada Tahun 2014* (Roadmap towards National Rice Surplus 10 million tons in 2014). In the course of drawing-up the program, a consensus on challenging issues, problems and opportunities for improvement of rice production in Indonesia was built among decision makers concerned as summarized in Table 3.4.1. Then various on-going programs in the both irrigation and agriculture sectors were reviewed aiming to choose promising programs which can play a key role in increasing rice production. The selected programs are to be implemented as components of paddy production supporting activities in the form of package menu in order to secure the synergistic effect of all the component programs for improving rice production. This new rice production policy was incorporated by BAPPENAS in its macro economy management scenario for 2012 as one of key elements relevant to sustainable socio-economic development activities. Further, MPW directed DGWR to concentrate its efforts on implementing irrigation components of the new rice production policy.

Table 3.4.1 Challenging Issues, Problems and Opportunities for Improvement of Rice Production

Challenging Issues	Problems
1. Increasing rice demand with increasing total population	1. Impact of global climate change and attack of plant pests
2. Limited availability of rice	2. Deterioration to infrastructure and environment for paddy cultivation
3. Food price increase	3. Conversion of paddy fields
	4. Farmers' limited access to financing soucers
	5. Competition among crop commodities
	6. High consumption of rice due to low diversification of non rice food consumption as a source of carbohydrate
	7. Less synergy among sectors as well as between central and rural institutions in supporting agricultural development, especially rice production

Opportunities for Improvement of Paddy Production
1. Gaps resulting from between potential and actual conditions at still high level
2. Available technology to production increase
3. Wide ranged land resource potentials for paddy fields, and dry fields for edry field state crops
4. Developed knowledge and skills of farmers, PPL (filed extension workers) and relevant agency staff
5. Availability of alternative crop development potential
6. Local government support
7. Availability of genetic resouces

Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

(2) Strategy

The followings focal points are the strategy of new policy for realization of rice surplus of 10 million tons in 2014:

- Expansion of irrigation area and proper management of farm land;
- Increase in paddy productivity;
- Improvement of production to logistic system; and
- Prediction of decreasing trend of par capita rice consumption.

(3) Target

Aiming to reserve rice of 10 million tons, the target paddy production in 2014 is established at 79.4 million tons as shown in Table 3.4.2, increasing by 3.7 million tons from the target set up in RPJM 2010-2014 of the agriculture sector as presented in Appendix B (Page B1-13).

Table 3.4.2 Annual Target of Rice Surplus

Year	Predicted Population (person)	Per Capita Consumption (kg/year)	Demand for Milled Rice (t)	Supply		Rice Surplus (t)
				Dry paddy (t)	Milled rice (t)	
2010	237,556,363	139.15	33,055,968	66,469,394	37,371,255	4,315,287
2011	241,095,953	139.15	33,548,502	68,596,415	38,567,136	5,018,534
2012	244,688,283	137.06	33,537,649	72,026,235	40,495,492	6,957,843
2013	248,334,138	135.01	33,526,799	75,627,547	42,520,267	8,993,467
2014	252,034,317	132.96	33,515,954	79,408,924	44,646,280	11,130,327

Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

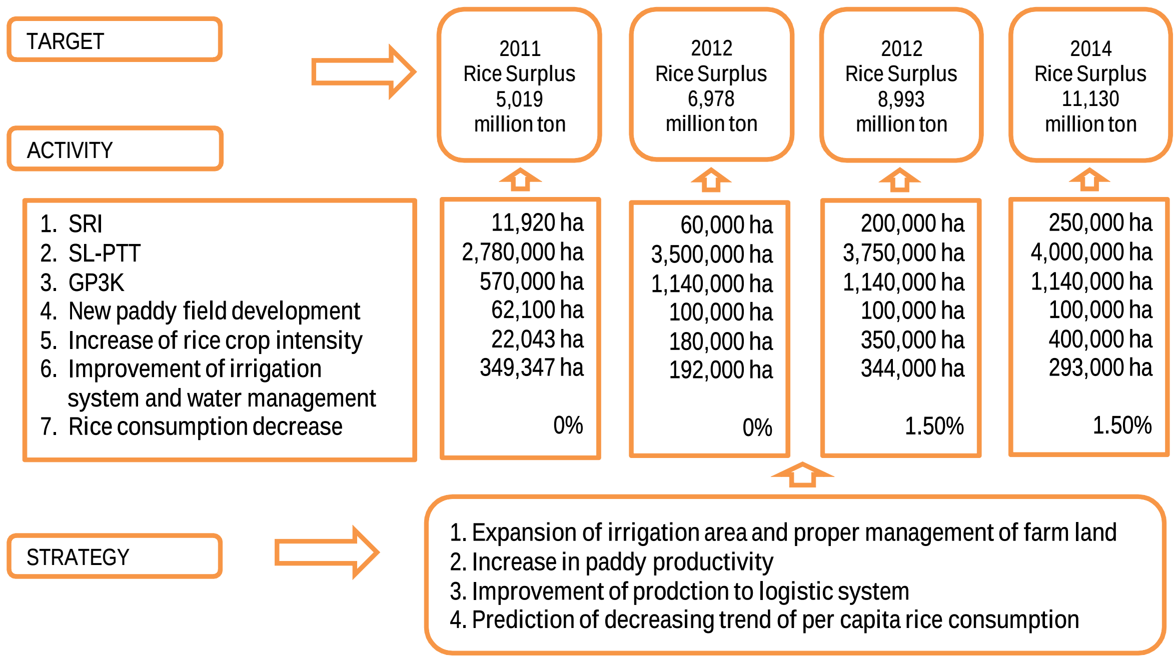
(4) Activities

To attain the above annual targets of rice surplus, the following activities have been selected as core pillars from existing programs in the both agriculture and irrigation sectors;

- System of rice intensification (SRI);
- Field school for integrated crop management (SL-PTT, *Sekolah Lapangan Pengolalaan Tanaman Terpadu*);
- Food crop productivity increase through corporative activity (GP3K, *Gerakan Peningkatan Produksi Pangan berbasis Korporasi*);
- New paddy field development;
- Increase of rice crop intensity;
- Improvement of irrigation system and water management; and
- Decrease of rice consumption.

(5) Roadmap

Based on the abovementioned strategy, target and activities, the roadmap for realization of 10 million tons rice surplus in 2014 is drawn up as illustrated in Figure 3.4.1.



Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

Figure 3.4.1 Roadmap for Realization of 10 million tons Rice Surplus in 2014

In the above strategy, focal points are the conservation of high productive paddy fields, betterment of production basis and enhancement of paddy productivity in the upstream part, the reduction of losses born from harvesting to post-harvesting and logistic stages in the midstream part, and the prediction of per capita rice consumption caused by diversification of people's tastes for food with the national economic growth in the downstream part.

3.4.4 Role of Irrigation Sector

(1) Activity

Among the seven activities, the improvement of irrigation system and water management activity should be initiated by DGWR in cooperation with provincial and district governments. Its main components are: i) Improvement of irrigation canal networks; ii) Rehabilitation of reservoirs and farm ponds (*Embung*); iii) Full functioning of surface irrigation systems; iv) Improvement of village irrigation systems; and v) Management of water resources.

The annual targets as well as expected areas planted and harvested with dry paddy production are set up as shown in Table 3.4.3.

Table 3.4.3 Target of Irrigation Water Management Activities

Item		Target				
		2011	2012	2013	2014	2015
1.	Irrigation Water Management Activities					
a.	Irrigation canal improvement (ha)	255,067	522,850	500,000	500,000	1,777,917
b.	Water source facility rehabilitation (ha)	50,680	23,555	45,000	45,000	164,235
c.	Surface irrigation system functioning (ha)	9,600	16,825	35,000	35,000	96,425
d.	Village irrigation improvement (ha)	33,000	21,000	25,000	30,000	109,000
e.	Water resource management (ha)	-	236,669	564,578	711,351	1,512,598
	Total (ha)	348,347	820,899	1,169,578	1,321,351	3,660,175
2.	Planted areas supplemented (ha)	174,174	192,400	344,879	293,505	1,004,958
3.	Harvested areas supplemented (ha)	168,147	185,743	332,946	283,350	970,186
4.	Additional paddy production (t)	-	819,591	1,363,805	1,246,440	3,419,836

Source: Roadmap Peningkatan Produksi Beras Nasional Menuju Surplus Beras 10 juta ton pada Tahun 2014

(2) Action Required for Realization of Targets in Irrigation Sector

In order to attain the above targets of irrigation water management for realization of the national rice reserve policy target by 2014, it is required to complete on-going major irrigation projects as scheduled for improving the function of irrigation systems covering at least 133,260 ha in total as listed up in Annex A1.7.2 of Appendix A (Page AA-78). Also, it is indispensable for monitoring the progress of each project. In addition, the existing irrigation schemes under the management of provincial and district governments will be rehabilitated and/or improved by using funds to be transferred from the central and also allocated by own budget sources. Under such situation, it is very important to share the latest information and data among the responsible management institutions from the central to district levels concerning the actual function of irrigation systems already under operation, the progress of on-going improvement and development activities of irrigation systems, as well as the identification and selection of candidate schemes for future planning and implementation. Aiming to meet such requirements, therefore, the existing management information systems in DGWR are required to be updated and enhanced with necessary basic data which will be used for practical decision making by each level to follow up the national rice surplus policy.

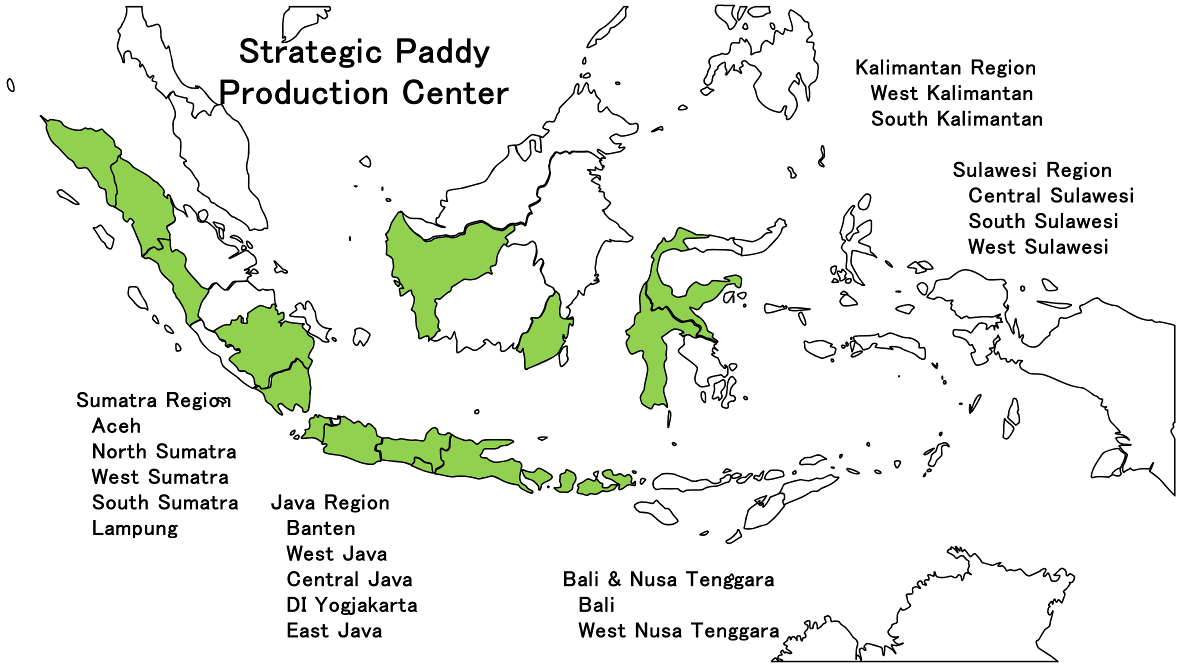
One of effective ways to meet the above requirement can be considered to re-build a framework of the future irrigation development and management strategy for the next 25 years from 2015. To do so, the first priority should be put over re-evaluation of water and land resources potentials available in the respective river basins in due consideration of the irrigation development performance for the past 25 years since the previous irrigation development framework was established under FIDP carried out by JICA in 1992 to 1993. The main target of re-evaluation is to clarify how much the both water and land resources potentials remain at present, where the potential areas exist, by what measures the remaining potentials can be utilized, and what targets are set up for exploitation of the remaining potentials, and so on.

In formulating the next 25-year framework of irrigation sector development, the both of above approaches will have to be synchronized through inter-ministry joint operation and in collaboration between the central and provinces/districts. From such viewpoint, it can be considered as the pressing need to re-build the existing databases and re-evaluate the available water and land resources in the respective river basins in the country.

3.4.5 Role of Agriculture Sector

(1) Activity

Aiming at the improvement of food crop productivity under irrigated condition, the present technical level of crop cultivation practices are to be graded up through SL-PTT activity and promoted by corporative groups, acting as key players for crop production, into which the existing farmers group (*Kelompok Tani*) and WUA are combined. To cope with limited availability of water resources for the dry season, a full-scale extension of SRI is to be made focusing on strategic paddy production centers coupled with strengthening of cooperation between relevant sectors as well as central and rural authorizes. ,



Source: Rencana Strategis Kementerian Pertanian Tahun 2010-2014

Figure 3.4.2 Strategic Paddy Production Centers in Indonesia

In order to realize the rice surplus of 10 million tons in 2014, the paddy production is targeted to increase by 13 million tons from 66 million tons in 2010 to 79 millions in 2014. In the roadmap, the direct effect of each activity on paddy production in 2014 is expected at 10% for introduction of SRI, 58% for implementation of SL-PTT, 22% for increase of food productivity by GP3K, 1% for new paddy field development, 7% for increase of rice crop intensity and 2% for improvement of irrigation system and water management.

(2) Action Required for Realization of Targets in Agriculture Sector

For attaining the above target level of paddy production, it is required to increase the national average paddy yield from 6.0 ton/ha in 2010 to 6.8 ton/ha in 2014. Therefore, the following attentions need to be paid to each agricultural activity:

- As for promotion of SRI introduction activity, it is considered to put a financial aid or financing plan and a technical support plan for tertiary or quarter canal development which is necessary for farmers to acquire on-farm level water management skill;
- Regarding implementation of SL-PTT activity, it is needed to promote, train and develop hard-working and innovative farmers as capable trainers of SL-PTT and also to focus on creation of awareness and motivation as core players among SL-PTT trainees, considering that the key factor to attain the paddy production target is their involvement in practicing the package program consisting of promotion of high quality and high yielding variety seeds, introduction of hybrid rice, switching from heavy use of chemical fertilizers to organic farming system, implementation of wide-area integrated pest management operation, and improvement of post-harvest system;
- Concerning food productivity enhancement, it is prerequisite to combine farmers groups and WUA into corporative groups in every villages and further to renovate the prevailing group working system on the community basis towards corporative and contract based crop cultivation system;
- In terms of new paddy field development and crop intensity increase for which irrigation water allocation is required, it is required to establish a cooperation system among officers in charge of water resource management, irrigation and agriculture of DGWR's regional offices, provincial governments' offices concerned and district governments' staff under the leadership of the district head who directs paddy production administration. Through this cooperative system, it should be done to select target areas for new paddy field development and also to cope with various problems in a flexible manner in the implementation stage of cropping and irrigation water distribution plans; and
- About decrease of per capita rice consumption which is different corresponding to the level of disposable income, it is assumed that people categorized as the low income level among high, middle, low and poverty levels will consume more rice after their income level is grade up from the poverty level benefitted from the national economic development, while per capita rice consumption by the high income level will decrease resulting from their diversified food intake. Accordingly, it is needed to renew the target level of par capita rice consumption in a flexible manner based on the actual trend of income level improvement by referring to the report on performance of the national macro economy issued by BAPPENAS in February every year.

CHAPTER 4 MAXIMUM UTILIZATION OF IRRIGATION WATER

4.1 Rationale

In Indonesia, many existing irrigation systems are not partly or fully functioning, even though irrigation water resources are ensured. These systems are featured by some physical troubles such as deteriorated and incomplete irrigation facilities, resulting in no supply or partial supply of irrigation water required for growing crops especially paddy under irrigated condition. On the other hand, the irrigation system, where enough irrigation water resources are available and irrigation facilities are fully functioning but diverted irrigation water is partly not used due to shortage of water users, is an exceptional case.

As clearly revealed in Table 2.2.1, the tidal irrigation area in swamp of Sumatra, Kalimantan and Sulawesi were reduced by half during the 15-year period between 1992 and 2007. Such fact was brought about by converting paddy fields to perennial crop fields in swamp transmigration areas where considerable immigrants had suffered from low paddy productivity of less than 1.0 ton/ha due to poor drainage condition or strong soil acidity caused by implementing excess drainage measures. As a result, they gave up paddy cultivation and then decided to participate in the small holder oil palm planting promotion program of MOA. Concerning rubber as another popular perennial crop in the country, there is rarely irrigation system where beneficiary farmers in a group intentionally converted paddy fields for rubber planting purpose, although it is found here and there in Sumatra that some individual farmers, giving up farming, planted rubber seedlings on their irrigated paddy fields before leaving from their places.

An issue regarded as more important is a serious situation that the present legal regulation for farm land conversion to non-agricultural land that has become a mere name, especially in surrounding areas of large cities and small towns in Java. Furthermore, no one has exactly grasped actual data concerning converted paddy field areas and unused quantity of irrigation water.

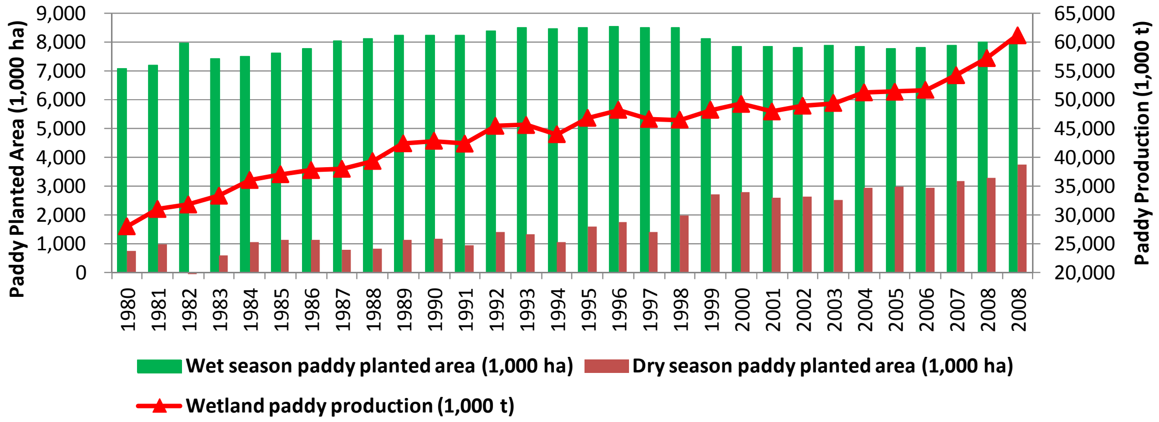
According to the rapid assessments done by DGWR on the current situation of irrigation infrastructure, the performance and sustainability of the existing surface irrigation systems tend to decline during the last 11 years between 1999 and 2010 as shown in Table 4.1.1. Such situation is principally caused by natural disasters, land use change especially over development in watershed forests, increased sedimentation, insufficient O&M works, and limited budget allocation to O&M works by governments at all levels. Among others, this tendency persists in the existing irrigation systems of less than 1,000 ha covering 55% in number and 45% in design service areas.

Table 4.1.1 Change in Irrigation Infrastructure Condition of Surface Irrigation Systems

Condition	1999		2010	
	(ha)	(%)	(ha)	(%)
Good	5,254,951	77.6	3,481,298	48.1
Minor / Moderate	1,389,938	20.5	3,043,313	42.1
Severe	126,127	1.9	705,572	9.8
Total	6,771,016		7,230,183	

Source: MPW, 2011

In paddy fields, paddy is normally grown under irrigated or rain-fed condition to the full extent during the wet season. Based on this assumption and by referring to the official data of BPS and MOA, it can be estimated that paddy planted and harvested areas have slightly gone up during the wet season from 8.11 million ha in 1999 to 8.17 million ha in 2010 and on the contrary increased during the dry season



from 2.69 million ha in 1999 to 3.95 million ha in 2010 as shown in Figure 4.1.1.

Source: Data base of Ministry of Agriculture

Figure 4.1.1 Past 30-year Tend of Annual Paddy Harvested Areas and Production

4.2 Approaches to Maximum Utilization of Irrigation Water

4.2.1 Basic Approaches

The ultimate goal for the maximum utilization of irrigation water is to contribute as much as possible to sustainable food security for the entire Indonesia's population on the one hand and to increase farmer's revenue from paddy cultivation on the other hand. Through efficient and rational use of precious water resources developed for the irrigation purpose, paddy cultivation is the most stable and profitable income source for farmers in Indonesia. As indicated by the abovementioned rapid assessment, however, the existing surface irrigation systems are not fully functioning at present. Considering such situation, it is needless to say that primary efforts have to be made for functioning properly irrigation systems as originally designed through implementation of rehabilitation works for malfunctioning facilities as well as round-up works for incomplete irrigation networks aiming to cope with physical issues. Furthermore, it is indispensable for realization and continuation of the national rice reserve target of 10 million tons set up in the new rice production policy that the synergistic effect of the package activities aiming at the improvement of farming practices and irrigation systems should be ensured through the maximum utilization of irrigation water.

The basic approaches for the maximum utilization of irrigation water are to focus firstly on optimum use of irrigation water for paddy cultivation during both wet and dry seasons and secondly on additional use of irrigation water if available for promotion of multiple cropping of paddy and non-paddy crops as much as possible. From the agricultural viewpoint, the main issues of the basic approaches are:

- Modernization of farming system for the maximum utilization of irrigation water; and
- Introduction of non-paddy crops paying attention to crop selection criteria, crop profitability, crop marketability, setting-up of cropping pattern, and improvement of crop productivity.

Besides, the key element of the basic approaches should be the participatory approaches based on the coordinated action between farmers as water users and officials concerned as water suppliers with the following three steps:

- Inventory on irrigation water supply and irrigation system management conditions;
- Study and planning on possibilities of introducing improved farming practices on the premise that the irrigation system is fully functioning for the full use of irrigation water; and
- Implementation of introduction plans in the form of packaged programs comprising irrigation water saving practices, crop productivity improvement methods and farming system modernization measures.

In compliance with such participatory approaches to the maximum utilization of irrigation water, the existing irrigation systems are to be broadly classified in the following three categories:

- Category I: Irrigation systems with the full extent of dry season irrigation areas are to target on double cropping of paddy plus cash crops and/or leguminous crops grown during the later dry season;
- Category II: Irrigation systems with partial dry season irrigation areas are to direct to irrigated paddy cropping to the maximum limit plus rain-fed cash crops and/or leguminous crops; and
- Category III: Irrigation systems without dry season irrigation areas are to concentrate on rain-fed legumes during the dry season to a considerable extent aiming to increase productivity of wet season paddy through enhancement of soil fertility.

The basic agricultural approaches for each category of irrigation system are as follows:

- Category I irrigation areas: With the most emphasis on the activity No. 5, crop intensity increase, of the new rice production policy, the triple cropping system of paddy growing short-term maturity varieties during the later part of dry season should be introduced if irrigation water resources are available, contributing to the maximum utilization of irrigation water. Furthermore, additional cropping systems are to be practiced during the later part of dry season every two years such as: i) to leave paddy fields fallow in a wide area for making intermittent period without rice plants with the aim of preventing paddy field from a hotbed of harmful insects caused by year-round paddy cultivation; ii) to grow green manure crops in order to improve soil fertility; and iii) to raise cash crops for diversifying farm income sources of smallholder rice cultivation farmers;
- Category II irrigation areas: For stabilizing irrigation water resources during the dry season, the construction of water source facilities with reservoirs as well as the recovery and strengthening of water resources conservation capacity in catchment areas are most effective, but the both need to be implemented in the medium to long run. In irrigation areas where no required water for irrigated cropping during the dry season can be temporally or permanently secured, the activity No. 1, introduction of SRI, and the activity No. 6, improvement of irrigation system and water management, should be implemented with the emphasis on rehabilitation of water source facilities, round-up of surface irrigation systems with incomplete irrigation canals and structures, rehabilitation of village irrigation systems and

strengthening of O&M activities of irrigation facilities required for rationalization of irrigation water management, contributing to the maximum utilization of limited irrigation water and expansion of dry season irrigated paddy cropping areas. In addition, the same farming practices adapted to the dry season cropping in Category I areas;

- Category III irrigation areas: Irrigation canal network development as one component of the activity No. 6 should be implemented as the starting point. As a result, water resources could be partly used for the dry season irrigated cropping and then the same activities adapted to the dry season cropping in Category II areas should be performed, contributing to the maximum utilization of irrigation water.

The schematic approach to prepare the cropping pattern for Category I areas is illustrated in Figure 4.2.1.

4.2.2 Modernization of Farming System

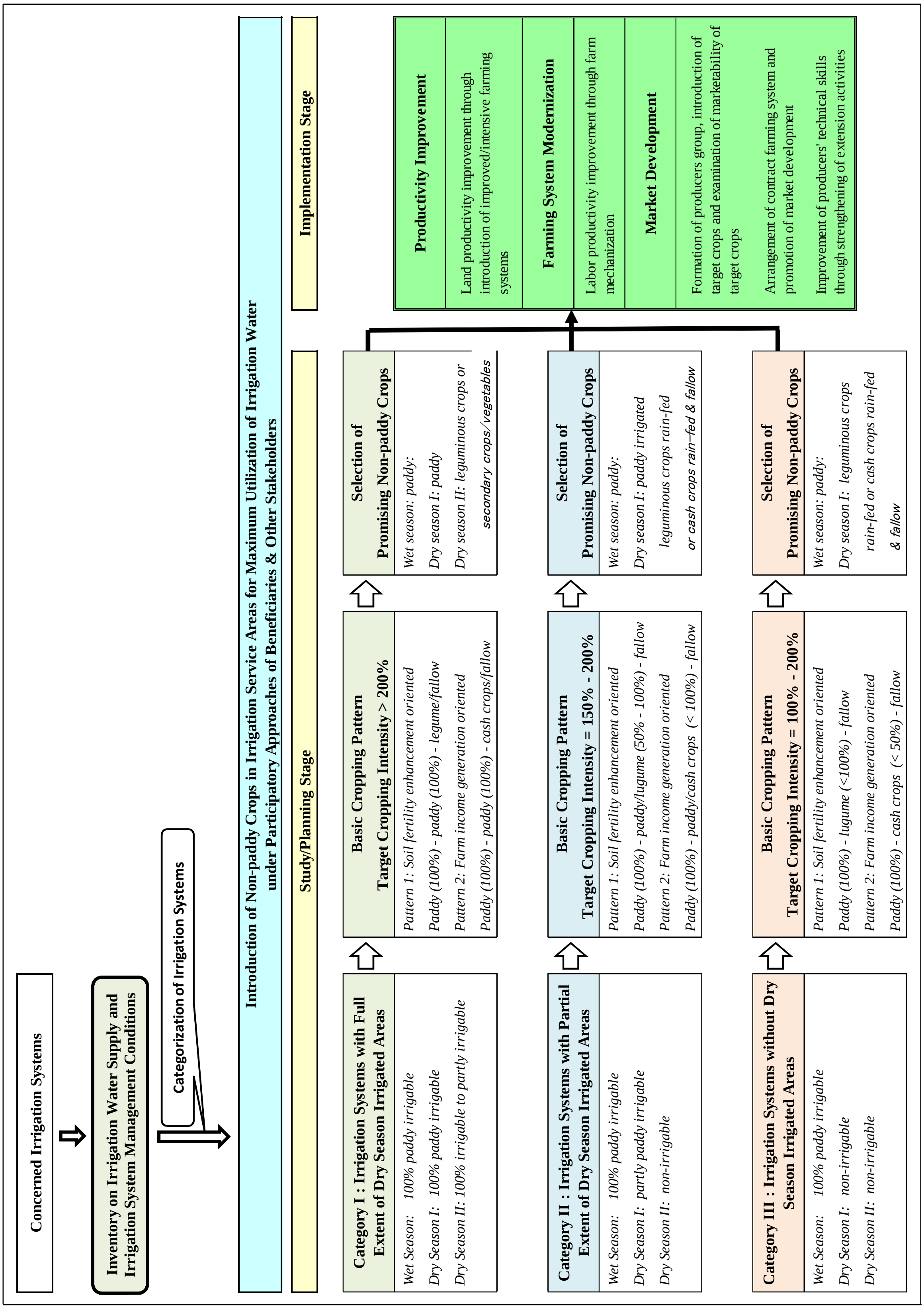
(1) Modernization of Farming System

The modernization of farming system in irrigation areas should be promoted focusing on the maximum utilization of irrigation water through effective practice of all the activities in one package in line with the new rice production policy and strategies. Among others, the two activities, the promotion of SRI method introduction and the implementation of SL-PTT, should be conducted as the core components of the package in the agricultural field.

Concerning SRI, practical trial operations were conducted at experimental plots/blocks established in sub-project areas of Yen Loan irrigation projects like Small Scale Irrigation Management Projects III (IP-499) and Komering Irrigation Project Stage II Phase 2 (IP-523) aiming at examination of effects of SRI on saving of irrigation water use. On the other hand, MOA carried out the first step program for training trainers about SRI method in 2005 and 2006, and then commenced demonstration works at selected sites from 2007. The progress up to 2009 was the implemention of a total of 229 SRI method dissemination program packages in 21 provinces and 95 SRI dissemination demonstration plot packages in 14 provinces throughout the country. Through these experiment and demonstration works, notable effects of SRI method on paddy yield and irrigation water saving have been obtained, but still on the plot basis. Among notable effects, the practice with low inputs including organic matters is highly expected in the new rice production strategies. The following are key points of SRI method:

- Transplanting of very young seedlings of 10 to 15 days old;
- Carrying out of rapid and shallow transplanting of one or two seedlings with wider spacing of 30 cm x 30 cm or 40 cm x 40 cm;
- Practicing of alternative wetting and drying during vegetative phase or keeping the soil moist but not continuously saturated; and
- Applying of compost in preference to chemical fertilizers.

As shown in Figure 3.4.2, the strategic paddy production centers in Indonesia are blessed with a plenty of rainfall during the wet season so that irrigation water is distributed in supplemental manner and paddy fields are always submerged even though drainage system is well functioning. Under such field condition, however, it is hard to control the soil moisture at required level for practicing SRI method properly.



Source: JICA Survey Team

Figure 4.2.1 Basic Approaches for Maximum Utilization of Irrigation Water

Therefore, the promotion of SRI method introduction in irrigated areas should be restricted to the dry season paddy cultivation, and also a specific course should be established in SL-PTT in order to disseminate and train the practices of SRI method to participant farmers. Furthermore, special attention should be paid to promote cattle fattening instead of draft animals in order to sustain raw material supply for compost preparation which is indispensable for popularize SRI method.

Regarding SL-TTP, MOA has promoted an integrated crop management (PTT) program targeting 2 million ha since 2007. For accelerating the application of this program, MOA also started SL-PTT programs centering in paddy, maize and soybean from 2008. During the 2-year period up to 2009, the PTT rice program covered 156,900 ha for introducing hybrid rice varieties and 3.6 million ha for spreading non-hybrid improved rice varieties. Budgets allocated to the both SRI and SL-TTP programs from the national budget (APBN) are transferred from MOA to district governments concerned for the program implementation purpose.

In the face of climate change and the difficulty to perform the expansion of new farm land, the increase in crop productivity can be considered as most fitting efforts. To support this, the following activities are required:

- Strengthening of seed distribution system;
- Provision of cropping calendar, climate data and soil test data;
- Formulation of swamp development model for paddy cultivation;
- Propagation and dissemination of technology guidance materials; and
- Creation of new technology for breeding new rice varieties and production of certified seeds.

In evaluating the results of previous PTT and SL-PTT activities, the new SL-PTT activity are set up with components such as SL-PTT paddy, seed aid, allocation of subsidized fertilizer, direct assistance of fertilizer, restoration of soil fertility, application of SRI method, and on-demand assistance services.

(2) Farm Mechanization

In Indonesia, a *borongan* system under which a package of works is conducted on contract basis has been prevailing as land preparation and harvesting works, especially in Java Island. The system has a measure to provide job opportunities for landless farmers or small-scale farmers in rural areas. Currently, however, hand-tractor hiring services become common practices in paddy cultivation areas for the land preparation purpose. Such services are provided by a publis sector represented by Farm Machinery Hiring Services Unit (UPJA, *Unit Pelaksana Jasa Alsintan*/) or by other private services providers on individual and entrepreneur basis. Paddy harvesting service providers using power threshers on contract basis are also getting popular in Java Island during the paddy harvesting season. Considering such situation, farm mechanization should be taken up as the supporting activity to promote the SL-PTT activity in family labor shortage areas.

The basic approaches for farm mechanization in irrigated areas aiming at the improvement of labor productivity are:

- Mechanization of land preparation is considered essential to curtail time required for the on-farm works, especially in irrigated areas, as well as to follow the irrigation water supply schedule decided by the irrigation commission for the respective service areas of irrigation systems. In this connection, the cropping schedules should be formulated taking into account the availability of hand tractors and the capacity of public and/or private service providers in the concerned irrigation service areas;

- Farm mechanization should be promoted based on careful study on labor availability and traditional labor sharing practices prevailing in irrigation service areas such as "*bagi-hasil*" (crop sharing) system for harvesting;
- For the promotion of farm mechanization, priority should be given over full utilization of public and/or private contract services instead of encouragement of personal investment in purchasing a farm machinery;
- Next step of farm mechanization in irrigated paddy cultivation areas will focus on threshing works of paddy and husking works of maize. Needs for mechanization of other farm operations such as planting and harvesting works are rather area-specific depending on labor availability and land holding size per farm in each irrigation service area;
- Farm mechanization should be synchronized with implementation of tertiary development works to increase density of farm roads passable by vehicles;
- Mechanization of inter-tillage and ridging operations with simple and small farming tools is considered necessary for cash crop cultivation after harvesting paddy, and
- Use of a small water pump for cultivation of cash/leguminous crops is to be promoted if available water of drains and ponds can be re-used.

4.2.3 Introduction of Non-paddy Crops

(1) Features Required for Candidate Crops

In irrigation service areas, the farmers' specific preference to grow paddy is generally very high and their intentions are to grow other crops when irrigation water supply is sufficient. Taking such farmers' way of thinking in accout, the basic considerations on crop selection are to examine the possibility of introducing non-paddy crops in irrigated paddy fields focusing on;

- Target cropping season for examining the possibilities shall be the dry season, since the farmers' preference to plant paddy during the wet season is very high and the occurrence of wet injury are high if field crops and vegetables are cultivated on the same paddy fields during the wet season;
- Target crops shall be seasonal crops and not perennial crops including jatropha curcus;
- Possibility of introducing a new cropping pattern should be examined based on the originally planned cropping patterns corresponding to the originally planned irrigation water supply conditions in individual irrigation systems, and the currently practiced cropping patterns which indicate current irrigation water supply conditions as well;
- In the selection of candidate crops, the following issues should be taken into account;

  a. Technical potential and feasibility and social soundness for the introduction;

  b. Agricultural development direction of national, provincial and district governments as well as opinions of provincial and district agricultural offices;

c. In case the introduction of non-paddy crops is considered, profitability (net returns per ha) of candidate non-paddy crops should be equal to or not substantially lower than the profitability of paddy; and

d. Marketability of candidate crops and potential for developing intensive producing areas should be dully considered in the selection of candidate crops;

- Crops successfully cultivated around target areas might be selected as candidate crops, while adverse effects of such crop cultivation on irrigation efficiency should be considered; and
- Possibility of introducing sugarcane cultivation under irrigated condition in rotation with paddy as used to be widely practiced in Central and East Java is to be examined

(2) Crop Selection Criteria

For the selection of candidate non-paddy crops to be introduced in irrigation service areas, factors such as natural, agronomic, agro-economic and social conditions coupled with government agricultural development directions or strategies are to be examined carefully. Also greater attention is to be paid to the area specific conditions of a target irrigation service area. The conceivable factors and their selection criteria to be employed in the course of the examination are presented in Table 4.2.1.

Table 4.2.1 Conceivable Factors, Major Selection Criteria and Indicator for Crop Selection

Factor	Selection Criteria	Indicator
Natural condition	- Climatic conditions	- Temperature during growing season - Rainfall pattern (length of dry spell),etc.
	- Soil conditions	- Soil texture, surface soil pH, soil depth, drainabability, etc.
Current production level	- Cropped area in project area	- Cropped area in project area
Agronomic condition	- Field occupation period	- Length of field occupation
	- Adverse effect on irrigation efficiency	- Risk of breaking-down of plow pan
	- Potential land productivity	- Expected yield level
	- Poftential labor productivity	- Labor productivity compared with paddy
	- Labor requirement	- Labor requirement compared with paddy
Agro-economic condition	- Market accessibility - Market demand - Market risk (price fluctuation) - Production cost - Net return/gross return - Crop profitability (net return/ha)	- Road condition to target market - Scale of target (consumer) market - Annual price fluctuation - Production cost compared with paddy - Percentage of net return to gross return - Comparison of net return/ha with paddy
Social condition	- Farmers experiences/skills - Farmers acceptance/intention	- Extent of cultivation of subject crops in project area
Agricultural development directions/strategies	- Provincial/district government development direction	- Selected as target crops in agriculture development direction
	- Opinion of province/district agricultural offices	- Introduction in irrigated areas supported or not

Source: JICA Survey Team

The selection criteria listed in Table 4.2.1 could be classified into two groups. The first consists of those which decisively determine the possibility for the immediate introduction of subject crops in cropping patterns. The second involves those which may affect the same to a certain extent but not decisive or which could be improved through the farm management improvement, agronomic countermeasures and extension efforts. The classification of the criteria is presented in Table 4.2.2.

Table 4.2.2 Decisive and Non-decisive Criteria for Crop Selection

Selection Criteria	Note
Decisive Selection Criteria	
- Temperature during growing season	- Difficult to improve condition
- Soil texture	- Difficult to improve condition
- Surface soil pH	- In extreme case, difficult to improve
- Drainabability	- Improvement will be costive
- Cropped area in project area	- Indicate farmers experiences/skills & acceptance
- Crop profitability	- Depending on productivity; could be improved through agronomic measures and extension efforts to a certain extent
- Farmers experiences/skills	- Gradual improvement possible through extension efforts
- Farmers acceptance/intention	- Gradual improvement possible through extension efforts
- Market accessibility	- Improvement could be expected through improvement of marketing system
- Market demand	- Market development essential
Non-decisive Selection Criteria	
- Cropped area in project area	- Could be improved through extension efforts, farm management improvement and agronomic countermeasures
- Market risk (price fluctuation)	- Common for vegetables & measures to alleviate adverse effect to be incorporated in the introduction plan
- Provincial/district government development direction	- To be taken into consideration in the selection

Source: JICA Survey Team

The crop selection criteria, indicators and ratings of the indicators proposed in the present Study are shown in Table 4.2.3.

Based on the criteria presented in Table 4.2.3, candidate non-paddy crops with a wide range of suitability to elsewhere in the country are selected as follows:

- Food crops other than paddy are maize, soybean, mung bean (green gram) and groundnut; and
- Cash crops are chili, shallot, long beans, eggplant, cucumber, amaranthus as a leaf vegetable (*bayam*) and sweet corn.

As the Soil Research Institute of MOA studied land suitability of overall crops grown in Indonesia, the results concerning the above candidate crops are summarized in Annex B2.1.1.of Appendix B (Page AB-19).

(3) Crop Profitability

The profitability of candidate non-paddy crops is compared with that of irrigated paddy based on the net return and labor productivity. Further comparison is made with major perennial crops of the country such as rubber and oil palm as well as raw material crops for bio-fuel production like cassava and sugarcane taking into account the economic life of each crop. The crop budgets used for the comparison purpose are estimated on the basis of secondary data provided by central and provincial agricultural agencies concerned. The typical crop budget estimated for each crop is presented in Annex B2.1.2 to Annex B2.1.5 of Appendix B (Page AB-20 to AB-23)..

The profitability of candidate crops is compared by employing net return per ha and labor productivity as indexes as shown in Table 4.2.4.

Table 4.2.3 Criteria, Indicators and Ratings for Selection of Candidate Crops

Factor/Selection Criteria	Indicator	Rating		
		Supportive (S)	Moderately Supportive (MS)	Limitedly to Non Supportive (NS)
1. Natural Condition	Temperature, soil texture, drainability etc (Appendix 1)	See Appendix 1	-	-
2. Current Production Level				
Cropped Area in Project Area/ Possibility to Develop Producing Area	Cropped area in project sub-districts	2ry crops: > 200 ha vegetables: > 10 ha	2ry crops: 5 - 200 ha vegetables: 1 - 10 ha	2ry crops: < 5 ha vegetables: < 1 ha
2. Agronomic Conditions				
Field Occupation Period	Length of field occupation by subject crops	< 4 months	4 - 7 months	> 7 months
Adverse Effect on Irrigation Efficiency	Possibility of breaking down of plow pan	no - low	moderate	high
Potential Land Productivity	Expected yield level (ton/ha)	depending on crops		
Potential Labor Productivity	Labor productivity compared with paddy	< 90% of paddy	> 90% of paddy	-
Labor Requirement	Labor requirement compared with paddy	< 90% of paddy	> 90% of paddy	-
3. Agro-economic Conditions				
Market Accessibility (to Major Market)	Road condition to target market	good (highway)	moderate (well paved road)	poor (poorly paved road)
	Distance (time required to target market)	short/< 1.5 hrs	intermediate/1.5 - 3.0 hrs	long/> 3.0 hrs
Market Accessibility (Processing Factory)	Accessibility to processing factory	easy	not easy	-
Market Demand	Scale of target (consumer) market	large scale consumers market	medium scale consumers market	small scale consumers market
Market Risk (price fluctuation/perishable)	Annual price fluctuation (highest/lowest x 100)	low/annual fluctuation: < 120%	moderate/annual fluctuation: > 200%	high/annual fluctuation: > 200%
Producers Bargaining Status	Producers bargaining power on commodity pricing	strong/producers > market/market agent	equal/producers = market/market agent	weak/producers < market/market agent
Production Costs	Production cost comparison with paddy	< 100%	> 100%	-
Net Return/Gross Return	% of net return to gross return	> 60%	30 - 60%	< 40%
Crop Profitability (net return per ha)	Comparison of net return/ha to paddy	> 125%	70% - 125%	< 70%
Initial Investment Amount	Annual depreciation cost of initial investment	no depreciation	less than 10% of net return	> 10% of net return
Adoptability of Intensive Farming	Possibility of adoptability	high	medium	low
4. Social Conditions				
Farmers Skills/Experiences in Cultivation of Subject Crops Farmers Acceptance/Intention	Extent of cultivation of subject crops in project area	commonly cultivated in project area	limitedly cultivated in project area	not cultivated in project area
5. Agricultural Development Directions/Strategies (province/district)				
Agricultural Development Direction/Province	Selected as target crops in development direction	selected as target crops	-	-
Agricultural Development Direction/District	Selected as target crops in development direction	selected as target crops	-	-
Opinion of Province/District Agricultural Office 3/	Introduction in irrigated areas supported or not	supported	-	-
6. Formation of Producing Area				
Current Cropped Area in Project Area	Current Cropped Area in Project Area	2ry crops: > 200 ha Vegetables: > 10 ha	2ry crops: > 5 - 200 ha Vegetables: 1 - 10 ha	2ry crops: < 5 ha Vegetables: < 1 ha

Source: JICA Study Team

Table 4.2.4 Net Return and Labor Productivity of Candidate Crops

Crop	Yield (t/ha)	Net Return (Rp 1,000/ha)	Net Return Index	Labor Productivity* (Rp 1,000/man-day)	Labor Productivity* Index
Paddy	6.0	11,262	100	167	100
Maize	6.5	10,495	93	195	117
Soybeans	1.5	4,040	36	122	73
Mung beans	1.1	4,520	40	110	66
Groundnut	1.5	9,543	85	183	110
Chili	10.0	28,770	255	250	150
Shallot	10.0	35,781	318	235	141
Long beans	8.0	7,997	71	240	144
Eggplant	12.0	12,060	107	164	98
Cucumber	15.0	10,627	62	132	135
Amaranthus	6.0	7,012	80	225	128
Sweet Corn**	10.0	9,000	86	214	116
Cassava	25	9,693	250	194	157
Sugarcane***	120	28,196	83	263	123
Rubber****	1.55	9,304	80	206	180
Oil Palm*****	11.9	6,984	62	388	299

Note: 1/; gross return/labor requirement 2/; fresh yield 3/; average of 3 years
4/; average of 19 years (from planting) 5/: average of 24 years (from planting)

Source: JICA Study Team

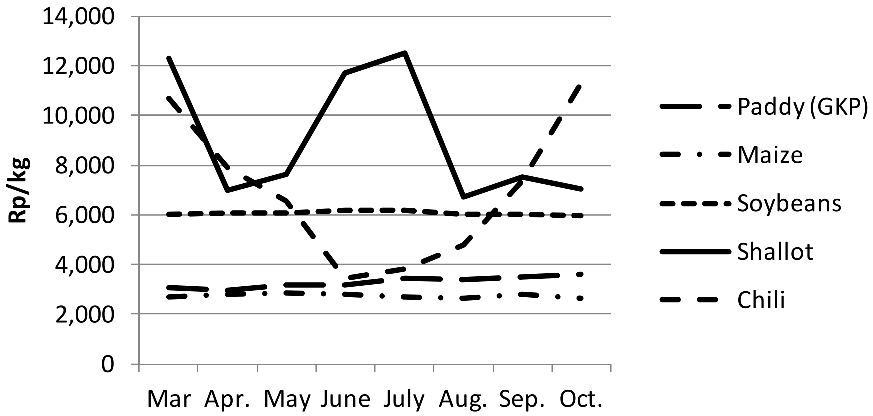
As shown in Table 4.2.4, shallot and chili could be defined as high-value crops (HVC) and maize, groundnut, long beans, eggplant, cucumber and sweet corn may be categorized into moderate-value crops (MVC) when estimated yield levels are attained. The profitability of cassava is substantially lower than that of paddy when its field occupation length is taken into consideration. Similarly, the profitability of sugarcane looks higher than paddy. However, when its growth length of 1 year is taken into account, the same result as cassava is obtained. The profitability of estate crops is also rather limited if compared on the basis of 1-ha unit area, while the labor productivity of these crops for the harvesting period is about two to three times of that of paddy.

Naturally, crop yield levels affect largely both net return per ha and labor productivity. In this regard, an increase in the productivity through the introduction of improved and intensive farming practices or crop management is essential for improving profitability and farm income in irrigation service areas.

(4) Crop Marketability

The marketability of agricultural products is to be assessed from the viewpoint of accessibility to markets in the case of secondary crops and vegetables or processing factories in the case of cassava and sugarcane as well as market demand, market risk caused by price fluctuation and production trends in competitive producing areas. In general, the marketability of paddy and secondary crops like maize, soybeans, mung beans and groundnut is rather stable compared with vegetables. In selecting candidate non-paddy crops to be introduced in irrigation service areas, the marketability of target crops should be carefully examined. In addition, measures to ensure marketing of products such as arrangement of contract farming system and promotion of market development should be accommodated in formulating a crop production plan.

Market prices of agricultural products usually show seasonal fluctuations and decline at harvesting time due to oversupply of products to markets. Drastic fluctuations of market price from perishable vegetables are commonly reported. Furthermore, post-harvest losses are large in the course of transportation. The producers' price trends of paddy, maize, soybeans, chili and shallot in 2011 are reported by MOA as illustrated in Figure 4.2.2.



Note: GKP (gabah kering panen); field dry unhusked ric
Source: Buletin Informasi Pasar, 2011, Directorate General of Processing and Marketing, MOA

Figure 4.2.2 Producers' Prices of Selected Crops in Major Producing Areas in 2011

(5) Setting-up of Cropping Pattern

In conformity with the basic agricultural approaches for the three categories of irrigation systems as described in Chapter 4.2.1, alternate cropping patterns applicable during the dry season are set up as shown in Table 4.2.5.

Table 4.2.5 Alternate Dry Season Cropping Patterns for Irrigation Service Areas

Dry Season Irrigation Water Supply	Wet Season Cropping Pattern	Early Dry Season Cropping Pattern	Late Dry Season Cropping Pattern
Full supply	Paddy, ordinary method	Paddy irrigated with SRI method	Legume rain-fed
		Paddy irrigated with ordinary method	Cash crops rain-fed
Partial supply	Paddy, ordinary method	Paddy irrigated with SRI method	Legume rain-fed
		Alternatively rain-fed cropping of cash crops and legume in 2-year rotation	Fallow
No supply	Paddy, ordinary method		

Source: JICA Survey Team

Focal points in Table 4.2.5 are as follows:

- In irrigation service areas where paddy is fully grown during the early dry season by applying SRI method coupled with organic farming method sufficiently, leguminous crops should be cultivated during the later dry season under either irrigated ot rain-fed condition. In case of growing paddy by ordinary method, however, cash crops either HVC or MVC should be cultivated to the full extent during the later dry season aiming to supplement farm income because its paddy yield is lower in comparison with that of SRI method ;
- In irrigation service areas where paddy is partially grown during the early dry season due to

the limited availability of irrigation water resources, SRI method has to be applied aiming to enlarge irrigated dry season paddy planting areas as much as possible; and

- In irrigation service areas where no irrigation water is supplied during the dry season, rain-fed cultivation of cash crops either HVC or MVC and leguminous crops are encouraged by utilizing residual soil moisture immediately after completion of harvesting works of wet season paddy. In this case, cash crops and leguminous crops have to be alternatively grown in the form of two-year crop rotation.

(6) Improvement of Crop Productivity

In order to improve the productivity of candidate crops to be grown on irrigated paddy fields during off-season when no irrigation water is available, the key factor is an integrated effort toward encouraging farmers to utilize public supporting programs in positive manner. In parallel with on-going SRI promotion and SL-PTT programs for paddy, MOA has undertaken another SL-PTT programs focusing on maize and soybean. As SL-PTT programs include all the basic agronomic aspects necessary for improving crop productivity as listed in Chapter 4.2.2 (1), extension activities at grass-roots level for introduction of the above candidate crops should be more flexible to cope with specific conditions and farmers' needs in the respective irrigation service areas.

Among others, it is indispensable to enhance soil fertility of paddy fields in sustainable manner for improving the productivity of candidate crops and paddy as well. In this regard, it is also a prerequisite to promote cow feeding on community basis aiming to secure sustainable self-supply sources of organic materials for producing compost.

(7) Promotion of Market Development

Generally, market prices of commodities with limited demand and for fresh consumption are unstable and fluctuate substantially depending on volume and timing of shipment to markets. For the successful introduction of non-paddy crops, especially vegetables, it is essential for the both individual and group producers to make continuous efforts to penetrate in markets coupled with demand driven supports by agricultural agencies concerned. The basic approaches for promoting market development are;

- Production of candidate crops with uniform quality, certain volume and constant supply. In order to satisfy such prerequisite conditions, the following activities are necessary to be taken by producers and the agricultural agencies concerned:

  a. Strengthening of producers' bargaining power coupled with large capital investment and formation of producers' group for marketing HVC, especially perishable vegetables;

  b. Strengthening of extension activities for improving technical skills of producers to ensure sustainable production of high quality HVC and MVC; and

  c. Scheduled production and shipment of HVC and MVC under contract systems between producer groups and private sectors such as farm input supplier, seed supplier, wholesaler, large-scale retailer, processing factory and other stakeholders.

- Construction of post-harvest and marketing facilities for the modernization of post-harvest and marketing operations; and

- Organization of producer groups into a federation with the following functions:

a. Procurement and supply of farm inputs;

b. Provision of market and technical information to member groups,;

c. Unification of group shipment and marketing of products; and

d. Provision of credit services to individual group members.

4.2.4 Introduction of Freshwater Fish Culture and Non-food Crops

(1) Freshwater Fish Culture

If year-round surplus of irrigation water is available in an irrigation area, it is possible to introduce freshwater or brackish water fish culture by supplying surplus water to a new fish pond which is developed by utilizing a small swamp or depression with poor drainage condition located in or around the irrigation area. Such practice will not reduce the existing irrigation paddy field area and in contast will contribute to the maximum utilization of irrigation water. For any fish ponds which obey the rule of the Government Regulation No. 20 / 2006 on Irrigation, irrigation water is individually supplied. As long as the introduction of fish culture is restricted to the irrigation system where surplus of irrigation water resources is available, the original design irrigation area will not be reduced. In designing the drainage canal network, it is desirable to pay attention to the proper layout for preventing the mixture of discharge from paddy field and fish pond aiming at reduction of water pollution risk,

Usually, the water requirement of fish culture is set up at 6.0 L/s/ha for a freshwater fish pond and 1.2 L/s/ha for a brackish water fish pond. These water requirements are estimated based on assumptions such as culture period of 150 days with culture operations including dry-up of pond, cleaning of pond bottom and full watering to pond twice a year, water depth in pond of 1.5 m, percolation and evaporation losses at the same level as paddy field, use of aeration equipment and minimum extra water supply for freshwater fish culture, and intermittent diversion of supplemental freshwater for brackish water fish culture. The profitability of fish pond culture differs according to fish species. The double cropping of irrigated paddy is used as an index which is expressed at 100, the profitability index of fish pond culture with two harvesting times a year is estimated at 351 for tilapia, 155 for carp, 104 for catfish and 14 for gold fish. However, fish pond culture requires heavy self-investment for the construction of fish pond and the installation of necessary equipment as weli as annual high cash expenses to cover cost of fish fry, feeding materials and medicine. It also requires additional costs for securing alternative water sources for emergency relief and maintaining water quality, resulting in careful attention to control these risks.

For the implementation of inland fish culture in a freshwater fish pond which is newly constructed in and around an irrigation area, it is needed to acquire the right of irrigation water use for the agencies concerned in accordance with the rule of the Government Regulation No. 20 / 2006 on Irrigation and to apply to the concerned irrigation commission for registration of irrigation water user which will be listed in the annual irrigation water distribution plan on district base.

The present situation of fish culture and the inland fish culture policy under RPJM 2010-2014 in the fishery sector are summarized in Appendix B2.3.

(2) Non-food Crop Introduction for Bio-fuel Raw Material Production

Aiming to cover 5.1% of the total energy consumption in 2025 with bio-fuel, GOI in its National Energy Management Blueprint 2006-2025 has selected oil palm, jatropha, sugarcane and cassava as strategic bio mass crops. Among these, oil palm suitable for wet land and swamp as well as jatropha suitable for dry land are the perennial crop which requires no irrigation water supply even in young seedling planting stage and is recognized as raw materials for producing bio-diesel. Therefore, these two crops are not included in the objective crops for this Survey. Sugarcane and cassava can grow on both wet and dry crop fields, and can be used as raw materials for producing bio-ethanol. In Lampung Province of Sumatra, several bio-ethanol producing factories are under operation using molasses which are by-products of sugarcane processing, but they have not yet introduced a more efficient fermentation system using sugarcane juice.

In Indonesia, the growth period of sugarcane can be shorten up to 12 months under irrigated condition so that, if planted on paddy field, the two-year crop rotation system with paddy can be practiced. Since its crop water requirement is smaller than that of rice plant, the dry season irrigated paddy cultivation areas can be recovered to a certain extent by allocating surplus irrigation water to paddy fields. For the maximum utilization of irrigation water, therefore, sugarcane cultivation is useful for irrigation areas with the following conditions:

- Surplus irrigation water is available at the planting time of sugarcane;
- Dry farm land exists adjacent to irrigation areas; and ;
- A sugar mill factory is operating at the transportable distance within a time limit to avoid sugar content reduction.

Cassava has a merit to grow anywhere under rain-fed condition with a wide range suitability to soils for using as not only a staple food but also a feeding and food processing raw material. With the recent increase in market demand and farm gate price, many farmers have been planting cassava as their second crop even in irrigated areas. However, harvesting works of cassava adversely affects the soil physical condition of paddy field resulting in increase in percolation loss during the irrigation period. Furthermore, commercial based production technology of producing bio-ethanol from residuals of cassava starch production has not put into practice yet. In due consideration of such demerit, cassava planting in the irrigation area is nor recommendable.

The present situation of bio-fuel crop cultivation in Indonesia and the world is summarized in Appendix B2.2.

4.3 Examination on Possibility of Introduction of Candidate Crops

Findings and results of the present field survey made aiming at confirmation on possibilities of introducing candidate non-paddy crops in service areas of such Yen Loan financed four irrigation systems as Bili-Bili, Way Sekampung, Ciujung, and Batang Hari are presented in Annex B2.1.6 to Annex B2.1.9 of Appendix B (Page AB-24 to AB-27). Major findings obtained through the present examination on the possibility of introducing non-paddy crops are as described below.

4.3.1 Bili-Bili Irrigation System

In the Bili-Bili Irrigation System comprising of Kampali, Bili-Bili and Bissua sub-systems with the total design irrigation service area of 23,746 ha, currently irrigated areas cover 23,711 ha. Paddy is fully grown during both wet and dry seasons followed by secondary crop cultivation during late dry season covering 40% of the area as envisaged in the original agricultural development plan. Major secondary crops are maize, soybean and mung bean, while vegetables are limitedly cultivated. Aiming to support improvement of farming practices, promotion activities of SRI method are conducted in irrigation service areas of Kampili and Bili-Bili sub-systems, while in Bissua sub-system area SL-PTT is operated in around 4,000 ha and SRI dissemination program has just started.

The allocated quantity and schedule of irrigation water from the Bili-Bili Reservoir are secured to enable beneficiary farmers to continuously cultivate paddy twice a year in the whole irrigation service area and grow additionally non-paddy crops in 40% of the area under irrigated condition. In order to maintain such given condition to contribute to the national food security in sustainable manner, the priority should be put over the productivity improvement of irrigated paddy. For this purpose, further extension efforts are required for practicing commonly integrated farm management and SRI methods by beneficiary farmers as much as possible through accelerating implementation of SL-PTT and SRI dissemination programs.

Considering the above situation, the basic approaches for introduction of non-paddy crops in the irrigation service areas of Bili-Bili Irrigation System are as follows:

- Application of irrigation water to be saved by practicing SRI method for growing the dry season paddy to the late dry season cropping under irrigated condition covering 50% of the irrigation service areas with formation of mutual agreement among stakeholders;
- Introduction of two-year rotation system during the late dry season comprising irrigated cropping and rain-fed cropping in the whole irrigation service areas;
- Administrative guidance to beneficiary farmers for growing leguminous crops under rain-fed condition during the late dry season with a two-year interval and by means of minimum tillage practice;
- Participatory selection of target crops grown under irrigated condition during the late dry season by beneficiary farmers; and
- Promotion of strategic group shipment and marketing of target crops by taking advantage of location near to Makassar as the largest consuming area in the region.

Therefore, the recommended cropping pattern and crops are as shown in Table 4.3.1.

Table 4.3.1 Recommended Cropping Pattern and Crops for Bili Bili Irrigation System

Cropping Season	Cropping Pattern/Intensity	Candidate Crops
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Irrigated paddy 100%	Paddy
Late Dry Season	First year: Irrigated target crops	Mung bean, soybean, leaf vegetables, etc.
	Second year: Rain-fed legume	Leguminous crops
Annual (>250%): paddy–paddy–secondary food crops/vegetables and paddy-paddy-leguminous crops		

Source: JICA Survey Team

The results of SWOT (strengths, weakness, opportunities, threats) analysis for introduction of non-paddy crops are as follows:

- Strength: Cropping intensity achieves the original plan of 240% with secondary crops grown in the late dry season as irrigation water is supplied as scheduled. Introduction of HVC is considered possible as farmers commonly practice to grow such crops in the late dry season;
- Weakness: Farmers' experiences and skills on HVC cultivation are limited. On-farm level water distribution is difficult due to insufficient density of tertiary and quarterly canals; .
- Opportunity: Irrigation service areas are located close to the provincial capital city of Makassar. Accessibility to the market in the city is fair in day time and good at night and down; and
- Threat: Careful consideration is needed in selecting HVC, especially perishable vegetables in order to avoid competition with the existing major temperate vegetable producing area in Malino.

4.3.2 Way Sekampung Irrigation System

The Way Sekampung Irrigation System consists of two major sub-systems, Bekri with 6,460-ha design service area and West Rumbia with 5,964-ha design service area. At present, irrigation water is supplied to both sub-system irrigation service areas during the dry season once in every two years due to shortage of irrigation water resources. Furthermore, insufficient irrigation water supply situation occurs even during the wet season after continuation of drought seasons.

Accordingly, the original cropping patterns consisting of paddy – paddy - secondary crops for 80% of service areas and paddy - secondary crops-fallow for 20% of service areas have not been realized. The current cropping patterns are specified as paddy - paddy/secondary crops - fallow in the year when irrigation water is supplied during the dry season, and paddy - rain-fed secondary crops - fallow in the year without irrigation water supply for the dry season. Major secondary crops grown include maize, groundnut and soybean. Vegetables commonly grown are chili, leaf vegetables, long beans and eggplant. Cassava cultivation on irrigated paddy fields is restricted to downstream parts of irrigation service areas having limited irrigation water supply. Implementation of SL-PTT and SRI method dissemination programs is tried in Lampung Tengah District, but its area extent is still limited.

In due consideration of the current situation in the Bekri and West Rumbia sub-irrigation systems, it is a prerequisite to investigate the actual condition of irrigation water distribution throughout the irrigation service areas aiming at the identification of technical and non-technical constraints and then to work out countermeasures to solve constraints to be identified. In the agricultural side, the priority should be given over improvement of paddy productivity in line with the new direction of national food security policy by implementing SL-PTT for paddy and SRI method dissemination programs. Supposing that irrigation water supply condition and paddy productivity will be improved to the original target level, the basic approaches for introduction of non-paddy crops in the irrigation service areas are as follows;

- Non-paddy crops either HVC or MVC for the purpose of earning cash income should be introduced during the early dry season in the year without irrigation supply, which are grown under rain-fed condition by utilizing residual moisture at sowing time immediately after completion of harvesting and threshing works of wet season paddy. Pump irrigation method can be applied to grow HVC if water is available in drains as currently practiced to a limited extent;

- Promising non-paddy crops are chili as HVC, and maize, groundnut, long beans, cucumber and sweet corn as MVC. Introduction of these crops should be supported by providing beneficiary farmers with frequent opportunities to attend training courses under SL-PTT programs;
- Leguminous crops aiming to enhance soil fertility should be introduced during the late dry season in the year with dry season irrigation water supply, which are grown under rain-fed condition by utilizing residual moisture at sowing time immediately after completion of harvesting and threshing works of early dry season paddy; and
- Establishment of effective marketing systems of HVC focusing on formation of producers' groups, contract farming, group shipment and group marketing

Therefore, the recommended cropping patterns and crops are as given in Table 4.3.2.

Table 4.3.2 Recommended Cropping Pattern and Crops for Way Sekampung Irrigation System

Cropping Season	Cropping Pattern/Intensity	Candidate Crops
In the year with irrigation water supply for dry season		
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Irrigated paddy 100%	Paddy
Late Dry Season	Rain-fed legume 100%	Leguminous crop
Annual (<300%): paddy-paddy-legume		
In a year without irrigation water supply in dry season		
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Rain-fed target crops	Mung beans, soybeans, vegetables
Late Dry Season	Fallow	No crop
Annual (<200%): paddy-secondary food crops/vegetables-fallow		

Source: JICA Survey Team

The results of SWOT analysis for introduction of non-paddy crops are as follows:

- Strength: The Bekri Sub-irrigation System is located close to the Sumatera Highway with about 1.0 to 1.5-hour driving distance to the provincial capital early in the morning and night, while the service areas of West Rumbia sub-irrigation system are vegetable cultivation areas where chili, leaf vegetables, long beans, egg plant and cucumber are commonly grown;
- Weakness: Due to limitation of water resources, two-year rotation system of dry season irrigation water supply is forced to be practiced throughout the both irrigation service areas of Bekri and West Rumbia sub-irrigation systems. Under the normal traffic condition, at least three hours are required for transporting products from the service area of West Rumbia sub-irrigation system to the provincial capital;
- Opportunity: As few farmers groups growing vegetables have tried to penetrate in markets at Jakarta, chances to expand such activities can be expected with participation of more producers as well as public and private stakeholders; and

- Threat: Irrigation areas located closer to the capital city become strong competitors as many farmers commonly practice vegetable cultivation in these areas..

4.3.3 Ciujung Irrigation System

The currently irrigated area of Ciujung Irrigation System covers 20,955 ha or 97.7% of the design irrigation service area. The dry season paddy is grown on irrigated paddy field of 15,716 ha or 75.0% of the area, and also non-paddy crop cultivation during the dry season is practiced in another 4,191 ha, resulting in cropping intensity of 175%, which is slightly lower than the original target of 184%. Vegetables are commonly grown for the dry season.

As the Banten Provincial Agriculture Office has emphasized implementation of SL-PTT programs for paddy, maize and soybean, the total area of paddy cultivation based on SL-PTT reached 65,000 ha throughout the province in 2010. In Serang District, the actual performance was 20,000 ha for paddy, 450 ha for maize and 100 ha for soybean.

For more contributing to the national food security by increasing paddy production, primary effort should be made for maintaining the coverage of dry season paddy cultivation at 80% level in sustainable manner. In this connection, the basic approaches for the introduction of non-paddy crops in the irrigation service areas of Ciujung Irrigation System are as follows;

- Non-paddy crops to be selected during the early dry season are maize and groundnut, and those which for late dry season are chili, long beans, eggplant, cucumber, fresh sweet corn and leaf vegetables, taking into account such advantages that these crops are commonly grown in the existing irrigation service areas and no serious constraint for the crop growth is encountered except for fluctuation of market prices of vegetables;
- For the sake of improving productivity of the above MVC and HYC, extension efforts should be strengthened by applying the essence of SL-PTT for maize and soybean;
- For marketing vegetables in a competitive manner, the formation of producers groups should be promoted in combination with introduction of contract cultivation system with private sector as well as promotion of group shipment and marketing activities; and
- Leguminous crops should be introduced during the late dry season in order to maintain and enhance soil fertility in sustainable manner.

The recommended cropping patterns and crops are as given in Table 4.3.3.

Table 4.3.3 Recommended Cropping Pattern and Crops for Ciujung Irrigation System

Cropping Season	Cropping Pattern/Intensity	Candidate Crops
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Irrigated paddy 80%	Paddy
	Rain-fed target crops 20%	Maize, groundnut, chili, shallot
Late Dry Season	Rain-fed target crops 40%	Eggplant, cucumber, etc.
	Rain-fed legume 40%	Leguminous crops
	Fallow 20%	No crop
Annual (<280%): paddy-paddy-vegetables/legume and paddy-secondary food crops/vegetables-fallow		

Source: JICA Survey Team

The results of SWOT analysis for introduction of non-paddy crops are as follows:

- Strengthen: In elevated paddy fields in the irrigation service areas, vegetable cultivation is commonly practiced, and dry season vegetable producing areas have been established to some extent;
- Weakness: The irrigation service areas are located rather far from Jakarta, although the distance to the capital market is a 1 - 1.5-hour driving distance when traffic condition on the highway is not so congested. However, farmers' preference to paddy is still strong;
- Opportunity: Productivity of vegetables for the both early and late dry seasons could be achieved through strengthening of extension efforts; and
- Threat: The neighboring Tangerang District has established producing areas of chili and other vegetables so that competition with the products of this district will become more intensified.

4.3.4 Batang Hari Irrigation System

(1) Background

Paddy cultivation in the Batang Hari area started from the later part of 1970s when 4,000 mass transmigrated Javanese farm families moved out from the target reservoir area of Wonogiri dam in Central Java. The paddy cultivation areas further expanded by additional 3,000 farm families moved out from the same place by 1988. In order to supply irrigation water to about 3,000-ha rain-fed paddy fields which were allocated to the first group of migrants, one pump station was constructed along the main stream of Batang Hari River and three diversion weirs were facilitated on its three tributaries, i.e.; Mimpi, Palangko-Piruko and Siat. Due to the oil shock in the beginning of 1990s, the operation of pump station was stopped resulting from the difficulty of necessary budget allocation for purchasing high-priced fuel. Aiming to cope with such condition, a plan to construct headworks on the Batang Hari River, the idea of which had been made in the 1980s, was materialized so that Yen Loan (IP-419) for engineering services to cover survey and detailed design works was provided in November 1993. Based on the detailed design, the Batang Hari Irrigation Project was commenced from 1998 under Yen Loan (IP-478) signed in January 1998, aiming to construct Batang Hari Headworks as well as the upper and down reaches of the main canal. Following the construction works of main facilities, Yen Loan (IP-504) was agreed upon in July 2001 to construct the remaining part of the main canal as well as to implement land development works together with tertiary canal network construction works. Thus the irrigation water was again supplied to the Batang Hari irrigation area in May 2006 in the 12th year after the materialization of plan.

The original design irrigation service area of Batang Hari Irrigation System was 18,936 ha of which 15,271 ha were commanded by the newly constructed headworks on the Batang Hari River and the remaining 3,665 ha were provided with irrigation water by the existing diversion weirs on three tributaries. When the Batang Hari Irrigation Project was completed in 2006, the actual irrigated paddy field area was 5,836 ha comprising 5,036 ha commanded by the Batang Hari headworks and 800 ha commanded by the three diversion weirs on tributaries. It involves various factors in the low performance of irrigation area development as chronologically listed below:

- Firstly, insufficient disclosure or dissemination activities by the project executing agencies concerned to expected beneficiary farmers regarding the outline of Batang Hari Irrigation Project from the initial stage when the plan was materialized, triggering suspicion about the realization of irrigated farming among them;
- Secondly, delay of commencing education activities targeting local spontaneous migrants, who had less experience of paddy cultivation in their home places and moved in settlements along the upper and middle reach of the main canal, to encourage them to participate in irrigated farming; leading reduction of farmers' willingness to participation in the project;
- Thirdly, sudden rise of international rubber market price, accelerating farmers to participate in the poor smallholder rubber planting program promoted by MOA focusing on their 1-ha upland field which was allocated at the transmigrated time; and
- Fourthly, as a consequence of the above factors, slow progress of paddy filed development component which was another key component of the project to convert upland field, fallow land and rubber planted area to paddy fields, covering about 75% of the design irrigation service area of 18,936 ha.

(2) Present Situation

The economic base of Dharmasuraya District, newly founded in 2004, is the Batan Hari Irrigation System. Its total population according to the 2010 population census was 186,354. At present, 62% of the whole households of 56,000 are engaged in paddy cultivation as their main farm income sources and earn sub-income from rubber planting, while 29% is full-time rubber planting farmers. As of 2011 after three years from the project completion, the total irrigated paddy field area of Batang Hari Irrigation System has increased by 101 ha to 5,937 ha and freshwater fish culture ponds of 257 ha also receive irrigation water. Out of the total irrigated area, the Batang Hari main canal is commanding 5,137 ha by year-round irrigation water supply. As a result, the triple cropping of irrigated paddy is conducted in the net area of 2,260 ha, and the double cropping area covers the remaining 3,057 ha. Such fact reveals that paddy cultivation farmers have realized their farm income enhancement by using irrigation water to the maximum extent. In the tributary command area of 3,665 ha, however, only 571 ha of paddy field is under irrigated condition, 620 ha under rain-fed condition and 2,245 ha under fallow or non-agricultural use.

As of 2010 in the existing paddy field under Batang Hari Irrigation System, the average paddy yield was 4.45 ton/ha, and the total paddy production was around 62,000 tons from the annual harvested area of 13,555 ha. The paddy yield level of seventh to eighth cropping since 2008 has already reached nearly to the target yield level of 4.5 ton/ha during the wet season and 5.0 ton/ha during the dry season. In some part of the command area, the average yield exceeds over 6.0 ton/ha.

(3) Future Irrigation Water Use Plan

The Dharmasuraya District Government set up its strategic development policy for the Batang Hari Irrigation System up to 2014 based on the agreement with DGWR signed in June 2010 as follows:

- To increase new irrigation area commanded by the Batang Hari main canal by 2,000 ha;
- To provide rain-fed paddy area of 620 ha in the tributary irrigation area with irrigation facility;

- To increase fish pond area to 700 ha by adding new fish ponds of 443 ha; and
- To use irrigation water for small-scale drinking water supply purpose.

The change in irrigated paddy field since the commencement of the project is shown in Figure 4.3.1.

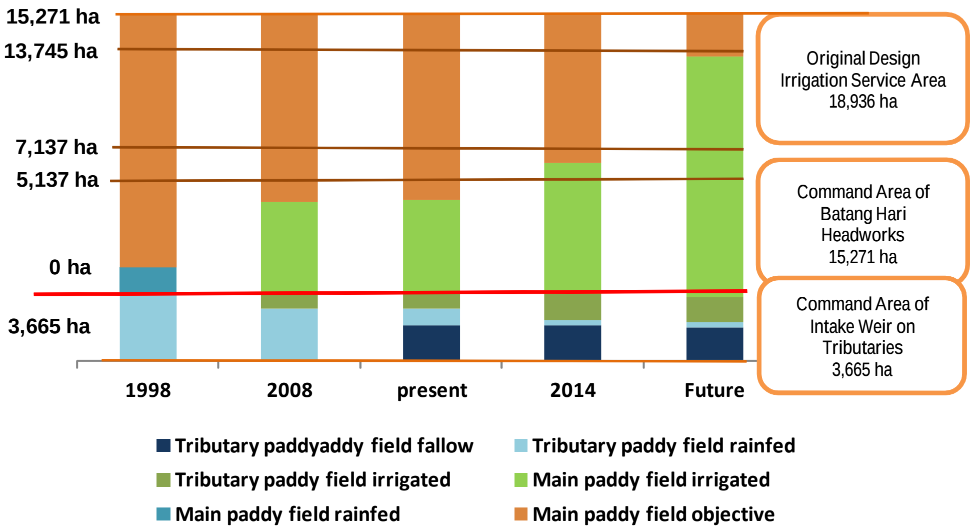


Figure 4.3.1 Change in Irrigated Paddy Field Area in Batang Hari Irrigation System

Regarding the Batang Hari Headworks, the design discharge is 25.2 m^3/s and the maximum intake capacity is 30.2 m^3/s for commanding the design irrigation area of 15.271 ha. Figure 4.3.2 shows the water use condition based on the actual and expected irrigation areas. If the above target of 2014 will be realized, the potential irrigation development area after 2015 will be 2,970 ha. For the small-scale drinking water supply project, 0.12 m^3/s of irrigation water will be allocated from the Batang Hari main canal, which is equivalent to irrigation area of 70 ha and estimated following the target of unit water requirement set in the United Nations' Millennium Development Goals.. This water supply system is planned to meet the future domestic water demand in 2026 for the predicted water supply population of 13,700 in the economic activity center of Dharmasuraya District. Since freshwater fish culture water requirement in the strategic development policy is overestimated, the irrigation area could be expanded more by reducing 12.0 L/s at the present planning level to 6.0 L/s at the standard level.

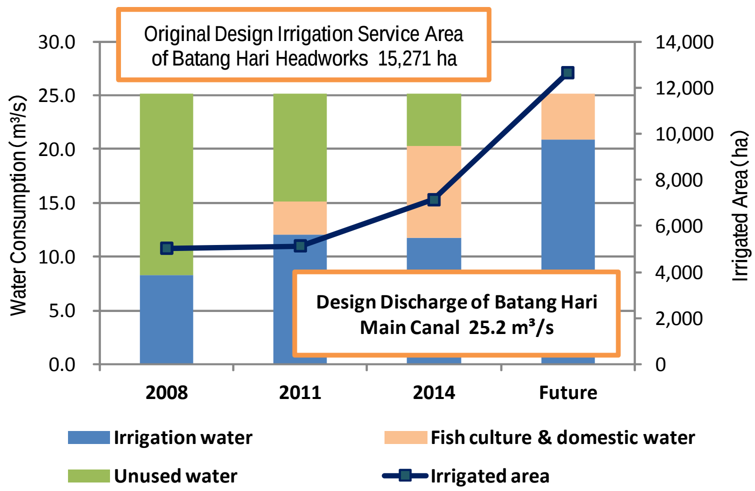


Figure 4.3.2 Change in Irrigation Water Allocation

(4) Modernization of Farming System

In order to take advantage of such opportunities, primary efforts should be made to bring high potential of irrigated paddy cultivation into full play in the not yet optimized service areas of Batang

Hari Irrigation System. In this regard, it is indispensable to offer various supporting services as incentives to non-paddy farmers focusing on frequent holding of SL-PTT courses coupled with technical and financial assistant menus to implement tertiary irrigation and drainage canal network development, introduction of cattle feeding in combination with compost producing facility construction, and so on. Prior to offers of such opportunities, it is needed to conduct socialization activities among stakeholders including beneficiary farmers, land holders on tertiary and quarterly canal alignment routes, elders who know the situation of community land, and local authorities at district, sub-district and village levels aiming to achieve a consensus about land acquisition for the construction of necessary irrigation and drainage facilities.

Taking the condition of year-round availability of irrigation water into account, the basic approaches for the introduction of non-paddy crops in the irrigation service areas of Batang Hari Irrigation System are as follows;

- Non-paddy crops for the late dry season cropping are introduced in command areas of the Batang Hari main canal, while those for the early dry season cropping are introduced in the whole command areas of the tributaries;
- Choice of the late dry season crop, either paddy or other food and vegetable crops like soybean and chili is based on preference of farmers who intend to practice irrigated crop cultivation three times a year;
- Maize is selected as the most recommendable dry season crop, taking an advantage of perpetually inadequate raw material supply to poultry feed processing industries depending on the high costly imported corn and also a long distance transportable feature;
- Introduction of leguminous crops during the late dry season is encouraged to farmers who intend to leave their paddy fields fallow after harvesting the early dry season paddy; and
- Practice of SRI method should be limited to paddy fields with good drainage condition throughout the dry season as the irrigation service areas are located in a high precipitation zone.

Therefore, the recommended cropping patterns and crops are as given in Table 4.3.4.

Table 4.3.4 Recommended Cropping Pattern and Crops for Batang Hari Irrigation System

Cropping Season	Cropping Pattern/Intensity	Candidate Crops
Command areas of Batang Hari main canal		
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Irrigated paddy 100%	Paddy
Late Dry Season	Irrigated paddy 50%	Paddy
	Irrigated target crops 25%	Chili, soybean
	Rain-fed legume 25%	Leguminous crops
Annual (<300%): paddy-paddy-paddy and paddy-paddy-vegetables/legume		
Command areas of tributaries		
Wet Season	Irrigated paddy 100%	Paddy
Early Dry Season	Rain-fed target crops 100%	Maize, soybean
Late Dry Season	Rain-fed legume 100%	Leguminous crops
Annual (<300%): paddy-maize- legume		

Source: JICA Survey Team

The results of SWOT analysis for introduction of non-paddy crops are as follows:

- Strengthen: Irrigation water can be supplied throughout the year and, even for the maintenance period of the main and secondary irrigation canal networks when water supply is cut off, soil moisture condition of paddy fields is suitable for growing non-paddy crops;
- Weakness: The location is far from large-scale vegetable consumption areas like Medan and Jakarta even if the Batang Hari irrigation service areas are located along the Trans-Sumatra Highway. No countermeasures are found in the command areas of tributaries with unstable and insufficient availability of irrigation water resources;
- Opportunities: Establishment of a supply center of transportable crops like soybean and chili to the neighboring Jambi and Riau Provinces by taking advantage of the shorter accessibility and lack of vegetable producing areas in target provinces; and
- Threaten: Conflicts of land use between agricultural purpose and settlement development purpose.

(5) Fish Culture

There are many depressed lands in the form of either inland valleies or small swamps which are either included or not included in the design irrigation service areas of the Batang Hari Irrigation System. In order to utilize such land resources for developing new fish ponds with water supply from the existing irrigation canal networks, it is a prerequisite to facilitate every fish ponds with tertiary drainage canals which are needed to connect to the downstream irrigation canal networks aiming at re-use of irrigation water. The comparioson of profitability of large- and small-scale freshwater fish culture with irrigated paddy cultivation and small holder rubber planting is as shown in Table 4.3.5.

Table 4.3.5 Comparison of Profitability among Paddy, Rubber and Freshwater Fish Farmings

Item		Newly Irrigated Paddy Cultivation	New Smallholder Rubber Planting	New Freshwater Culture	
				Large Scale*1	Small Scale*2
1	Project useful life	25 years	25 years	25 years	25 years
2	Annual production output	4.6 ton/ha x 2 times	1,516 kg/ha	12.0 ton/ha x 2 times	5.0 ton/ha x 2 times
3	Financial price of output at site	Rp. 3,200/kg	Rp. 11,000/kg	Rp. 10,800/kg	Rp. 8,750/kg
4	Annual gross revenue	Rp. 29.44 million	Rp. 16.68 million	Rp. 259.20 million	Rp. 87.50 million
5	Initial investment cost	Rp. 2.73 million	Rp. 57.00 million	Rp. 7.28 million	Rp. 7.28 million
6	Annual input cost	Rp. 13.68 million	Rp. 6.19 million	Rp. 204.02 million	Rp. 56.30 million
7	Annualized cost	Rp. 13.79 million	Rp. 8.47 million	Rp. 204.30 million	Rp. 56.58 million
8	Net revenue in total	Rp. 15.65 million	Rp. 8.21 million	Rp. 54.90 million	Rp. 30.92 million
9	Irrigation water requirement	1.65 l/s/ha	No water use	8.56 l/s/ha*3	5.79 l/s/ha*3
10	Factor adjustment to unit quantity of irrigation water	1/0.00165 = 606	Apply same size of paddy cultivation	1/0.00856 = 116.8	1/0.00579 = 172.7
11	Net revenue per 1.0 m³ of irrigation water	Rp. 9,484 million	Rp. 4,975 million	Rp. 6,412 million	Rp. 5,340 million

*Note: *1; Mixed freshwater fish culture comprising 45% for Ikan Nila, 40% for Ikan Mass and 15% for Ikan Lele *2; Mixed freshwater fish culture comprising 50% each of Ikan Mass and Ikan Lele *3; Water requirement consisting of daily loss by seepage and evaporation, daily supplement of fresh water and daily equivalent quantity of total replaced pond water for every fish culture period of 150 days as described in detail in Appendix B2.3.5.(5) on page B2-9*

Source: JICA Survey Team

(6) Implementation Procedure

In order to utilize irrigation water of the Batang Hari Irrigation System towards the maximum utilization, farmers' interests in irrigated paddy cultivation should be generated through sustainable efforts to carry out education activities by the Dharmasuraya District Government. Furthermore, it is recommended as the priority action to DGWR through Balai Sumatra VI office to incorporate the 2,000-ha new paddy field development plan into the improvement program of irrigation system and water management as well as to promote necessary budget allocation for realizing the plan under the most important policy framework of irrigation sector. It is also recommended to MOA through the Dharmasuraya District Government to apply the package program of SL-PTT activity as a follow-up measure to farmers who will participate in the 2,000-ha new paddy field development plan. Aiming to make SL-PTT activity effective, it is a prerequisite to select, train and utilize young farmers with a sense of leadership among younger members of local spontaneous migrant famililies whose livelihood depends on irrigated paddy cultivation as well as to establish an cooperation system among officers concerned under the direction of the head of Dharmasuraya District Government. In the existing irrigation area, it is also indispensable to promote group farming activity by hard-working and innovative farmers focusing on establishment of community based agricultural production system.

Typical samples of non-paddy crops currently grown in the respective irrigation service areas of Bili-Bili, Way Sekampung, Ciujung and Batand Hari Irrigation Systems are shown in Figure 4.3.1.

4.4 Implementation Procedure for Introduction of Non-paddy Crops in Irrigation Service Areas

If the introduction of non-paddy crops in the existing irrigation service areas is possible during the late dry season under either irrigated or rain-fed condition as well as during the early dry season under rain-fed condition, a systematic procedure as illustrated in Figure 4.4.1 will be required for implementation of mixed farming systems with target non-paddy crops in a synchronized manner among irrigation, agricultural and institutional sectors.

In connection with the above implementation procedure, it should be pointed out that the most important action to be taken firstly is to pick up a capable and independent organizer group from the third group like NGO aiming to secure smooth implementation through effective and timely activities for coordination among stakeholders of different position as well as between these stakeholders and beneficiary farmers coupled with empowerment of participants by allocating necessary budgets.

Irrigated dry season secondary crop (Mung bean)

Irrigated dry season secondary crop (Long bean)

Irrigated dry season secondary crop (Chili pepper)

Irrigated dry season secondary crop (Cucumber)

Rainfed dry season secondary crop (Maize)

Rainfed dry season secondary crop (Cassava)

Conversion to sugarcane field

Conversion to fish pond

Figure 4.4.1 Typical Samples of Non-paddy Product Introduction in Irrigation Systems

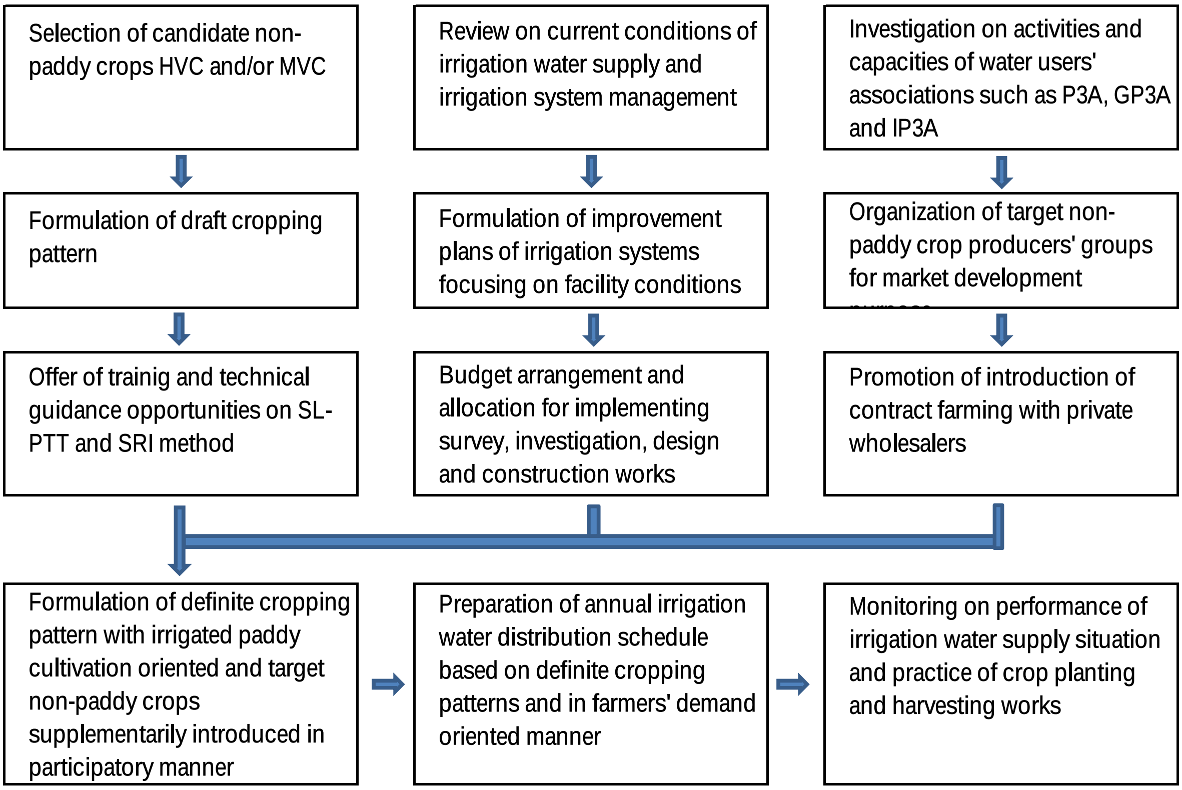


Figure 4.4.2 Implementation Procedure Flow for Introduction of Non-paddy Crops

CHAPTER 5 MICRO HYDROELECTRIC POWER GENERATION PLAN IN BATANG HARI IRRIGATION AREA

5.1 Circumstances of Hydroelectric Power Generation

5.1.1 Policies

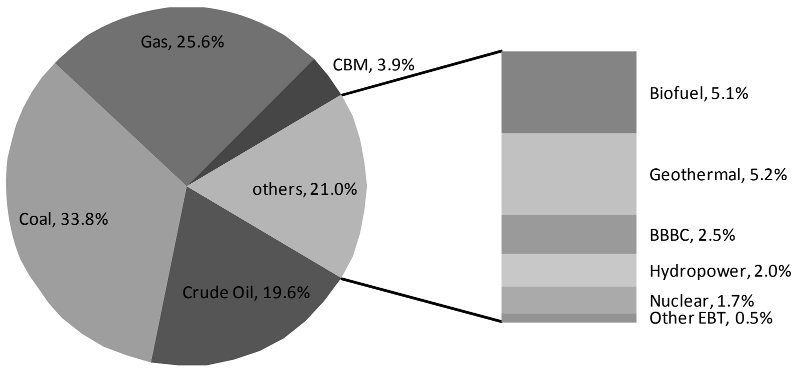
Hydropower development in Indonesia is implemented based on the strategy of energy diversification stipulated in Presidential Regulation No.5/2006 on National Energy Policy (KEN) and the National Energy Management Blueprint (BP-PEN) 2006-2025. The KEN sets the target share for new and renewable energy at 17% by 2025. As shown in Table 5.1.1 and Figure 5.1.1, the BP-PEN presents more concrete figures for the projection of energy mix from 2005 to 2025.

Table 5.1.1 Projection of Energy Mix

(Unit: million BOE)

Type of Energy	2005	2010	2015	2020	2025	
Crude Oil	524.0	550.7	578.0	605.8	638.9	19.6%
Coal	160.4	210.3	349.7	743.8	1,099.4	33.8%
Gas	212.8	363.7	382.5	477.1	832.0	25.6%
Coal Bed Methane	--	--	23.0	74.6	127.8	3.9%
Biofuel	--	32.5	89.0	102.4	166.9	5.1%
Geothermal	23.7	23.7	61.8	115.8	167.5	5.2%
Liquefied Coal	--	--	14.2	47.4	80.5	2.5%
Hydropower	34.0	41.7	56.6	60.5	65.8	2.0%
Nuclear	--	--	--	27.9	55.8	1.7%
Other alternative energy	1.6	3.5	7.4	11.7	17.4	0.5%
TOTAL	956.5	1,226.1	1,562.1	2,266.9	3,252.2	100.0%

Source: Blueprint Pengelolaan Energi Nasional 2006 – 2025, MEMR



Source: Blueprint Pengelolaan Energi Nasional 2006 – 2025, MEMR

Figure 5.1.1 Energy Mix in 2025

The contribution of hydropower was set at 65.8 million barrel of oil equivalent (BOE), which is 2.0% of the total energy consumption in 2025.

The Ministry of Energy and Mineral Resources (MEMR) is currently a plan known as "Energy Vision 25/25", which targets to achieve a higher share of new renewable energy in the national energy mix, amounting to 25% by 2025. Energy Vision 25/25 focus on two objectives; first is, to improve the utilization efficiency of energy use nationwide, and second is to diversify energy supply side with an emphasis on renewable energy.

5.1.2 Laws and Regulations

The hierarchy of the legal system in Indonesia is as shown in Table 5.1.2.

Table 5.1.2 Legal Hierarchy of Indonesia

	Indonesian		English
	LongTitle	Short Title	
1	*Undang-Undang Dasar 1945*	UUD 1945	1945 Constitution
2	*Undang-Undang*	UU	Law
3	*Peraturan Pemerintah*	PP	Government Regulation
4	*Peraturan/Keputusan/Instruksi Presiden*	*Perpres/Keppres/Inpres*	Presidential Regulation/Decree/Instruction
5	*Peraturan/Keputusan Menteri*	*Permen/Kepmen*	Ministerial Regulation/Decree

The process of hydropower development in Indonesia is regulated under the laws and regulations listed in Table 5.1.3.

Table 5.1.3 Laws and Regulations related to Hydroelectric Power Generation

	No.	Title	
		Indonesian	English
1	UU No.30/2009	Ketenagalistrikan	Electricity
2	UU No.30/2007	Energi	Energy
3	UU No.25/2007	Penanam modal	Investor
4	UU No.32/2009	Perlindungan dan pengelolaan linkungan hidup	Conservation and management of environment
5	UU No.33/2004	Perimbangan keuangan pemerintah pusat-daerah	Financial balance of central and local governments
6	UU No.7/2009	Sumber daya air	Water resources
7	UU No.15/1985	Mengatur usaha penyediaan ketenagalistrikan oleh PKUK/PIUKU	Regulation of electricity supply business by PKUK/PIUKU
8	UU No.10/1998	Perbankan	Banking
9	UU No.41/1999	Kehutanan	Forestry
10	PP No.5/2006	Kebijakan energy nasional	National energy policy
11	PP No.3/2005 (No.10/1989)	Penyediaan dan pemanfaatan tenaga listrik	Supply and utilization of electric power
12	PP No.26/2006	Mengatur usaha penyediaan dan pemanfaatan tenaga listrik	Regulation of electricity supply and utilization business
13	Kepres No.37/1992	Usaha penyediaan tenaga listrik oleh swasta	Electricity supply business by private sector
14	Perpres No.5/2006	Kebijakan energy national	National Energy policy
15	Kepmen ESDM No.2/2004	Kebijakan pegembangan energy terbarukan dan konservasi energy (energy hijau)	Policy on development of renewable energy and energy conservation (green energy)
16	Kepmen 1122K/30/MEM/2002	Pedoman pengusahaan pembangkit listrik skala kecil (PSK) tersebar	Guideline on small-scale power generation business
17	Permen ESDM No.2/2006	Pedoman pengusahaan pembangkit listrik tenaga energy terbarukan skala menengah	Guideline on medium-scale renewable energy power generation business
18	Permen ESDM No.5/2009	Pedoman harga pembelian tenaga listrik oleh PT.PLN (Persero) dari koperasi atas badan lain	Guideline on purchase price by PLN of electricity from cooperative
19	Permen ESDM No.31/2009	Harga Pembelian Tenaga Listrik oleh PT PLN (Persero) dari Pembangkit Tenaga Listrik yang menggunakan energy terbarukan skala lecil dan menengah atau kelebihan tenaga listrik	Purchase price by PLN of electricity from small and medium scale renewable energy power plant or excess power

Source: Micro-hydro Inventory in River Basin and the Managing Institution, DJSDA/PU

Among the above, the ministerial regulation (*Permen* ESDM No. 31/2009) issued in November, 2009 should be focused on. This ministerial regulation aims to enhance the electricity generated by small- and medium-scale renewable energy power plants or from excess power. Also, it mandates PLN to buy renewable generated electricity up to 10 MW. This regulation offers different prices for renewable energy generated in different regions.

- Rp 656/kWh × F for medium voltage interconnection; and
- Rp 1,004/kWh × F for low voltage interconnection.

F is the incentive factor determined by regions (1.0~1.2). In Sumatra, F is set at 1.2. PLN may buy electricity generated from renewable energy power plant at a higher price than the "floor price" provided by this regulation.

5.1.3 Supply-Demand Balance of Electricity

(1) Sumatra

1) Current condition

The electricity sales of PLN in Sumatra were 17.62 TWh in 2009 as shown in Table 5.1.4. The average growth rate from 2005 to 2009 is 8.7%, which is much higher than the 6.1% of the whole of Indonesia.

Table 5.1.4 Electricity Sales in Sumatra

Unit: TWh

	2005	2006	2007	2008	2009	Average
Sumatra	12.45	13.61	14.69	16.44	17.62	
Growth (%)	7.23	9.33	7.92	11.87	7.22	8.7

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

The total installed capacity for power generation in Sumatra in 2009 was 4,599 MW, the details of which are shown in Table 5.1.5.

Table 5.1.5 Installed Capacity for Power Generation in Sumatra

Unit: MW

Province	Type (owned by PLN)						PLN	IPP	PLN+IPP
	Diesel	Gas	Combined Cycle	Coal	Geo-thermal	Hydro	Total	Total	Total
Aceh	205					2	207		207
North Sumatra	53	306	818	490		140	1,807	10	1,817
West Sumatra	38			200		254	492		492
Riau	90	43				114	247		247
Kep. Riau	124						124		124
Bengkulu	17					236	253		253
South Sumatra	43	230		285			558	268	826
Jambi	43	62					105		105
Bangka Belitung	89						89		89
Lampung	96	21		200		122	439		439
Total	798	662	818	1,175	0	868	4,321	278	4,599

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

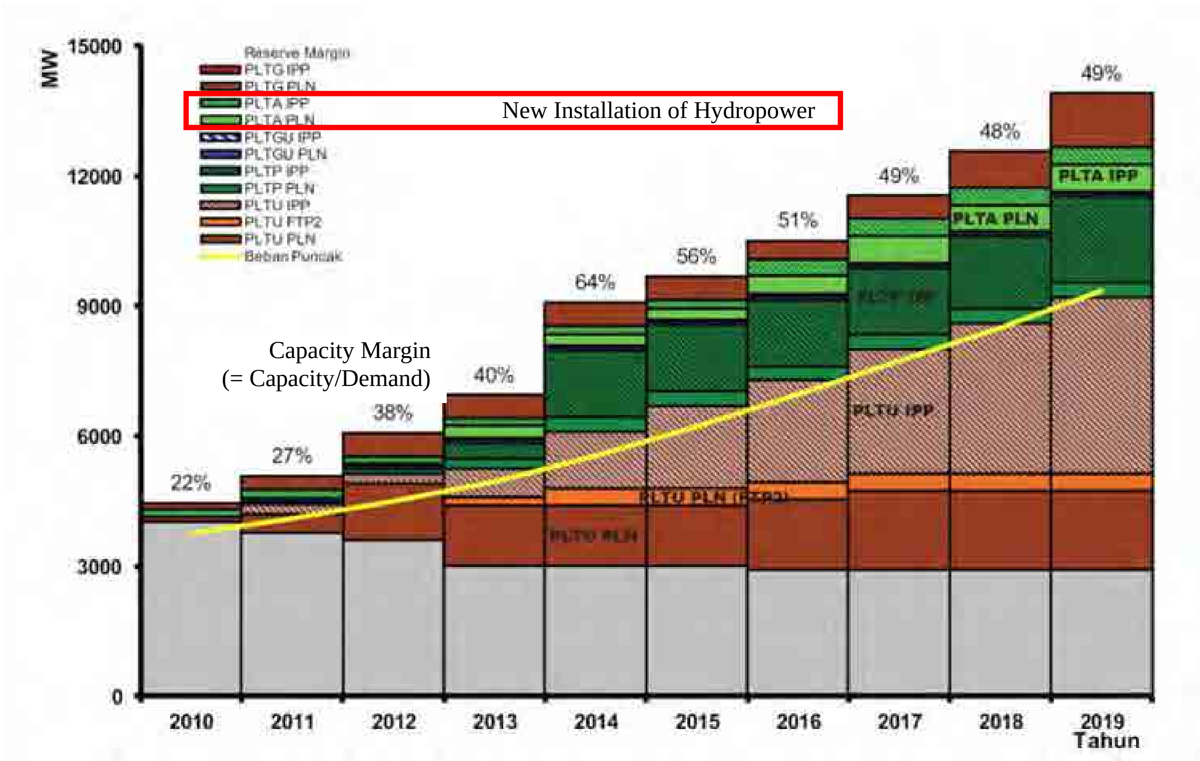
2) Future forecast

The *Rencana Usaha Penyediaan Tenaga Listrik* (RUPTL) 2010-2019 by PLN forecasts the future electricity sales and production as well as peak load in Sumatra as shown in Table 5.1.6 and Figure 5.1.2.

Table 5.1.6 Forecast of Electricity Sales, Production and Peak Load in Sumatra

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sales	TWh	18.60	20.36	22.37	24.77	27.84	31.33	35.25	39.30	43.45	47.99
Production	TWh	21.42	23.41	25.70	28.43	31.93	35.91	44.37	44.99	49.72	54.89
Peak Load	MW	3,743	4,099	4,478	4,958	5,553	6,219	6,965	7,731	8,505	9,355

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN



Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

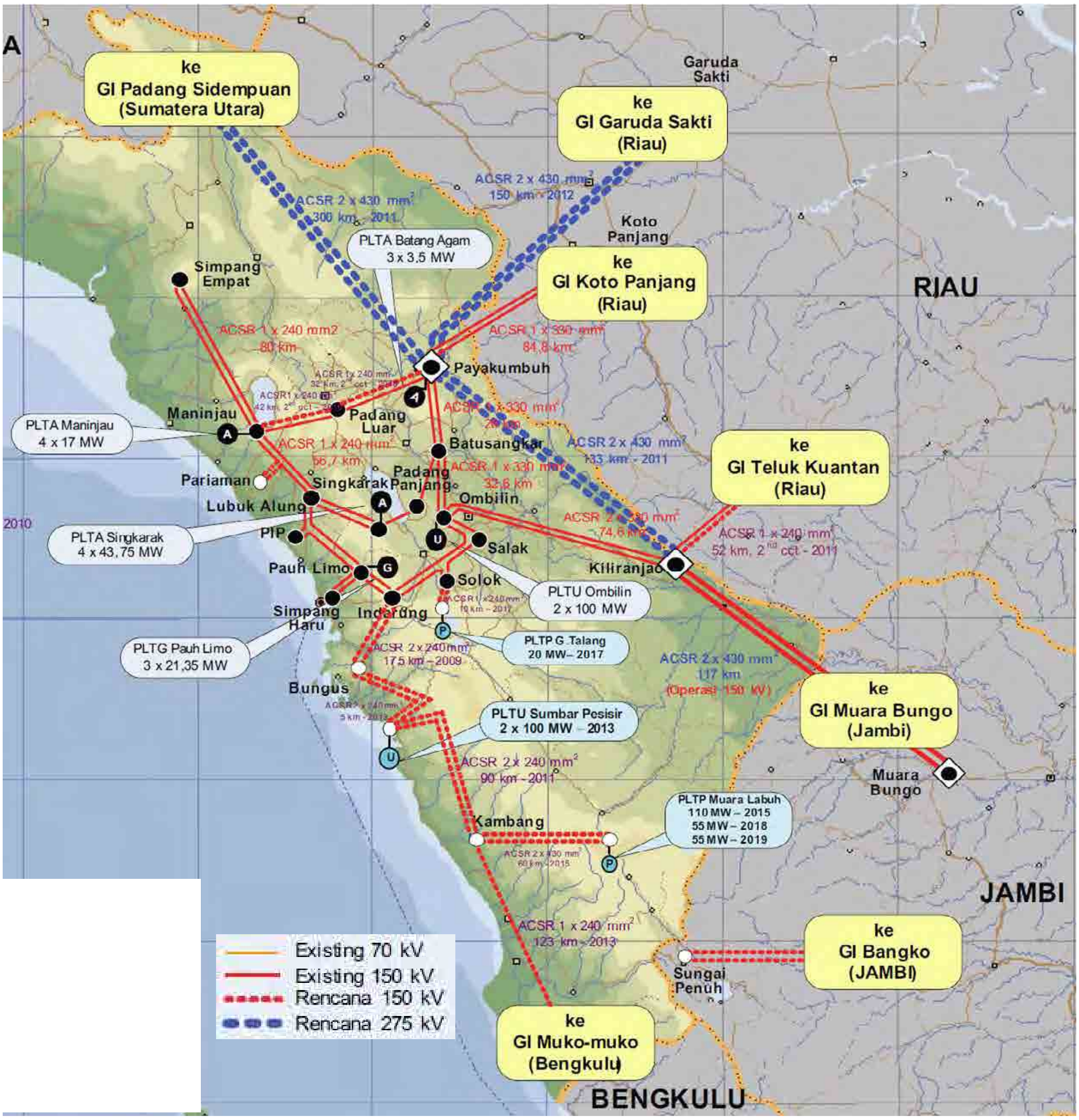
Figure 5.1.2 Generation Expansion Plan in Sumatra

(2) West Sumatra Province

1) Current condition

The electricity sales of PLN in West Sumatra Province were 2.01 TWh in 2009. The average growth from 2003 to 2009 is 6.2% per year.

The electricity supply of West Sumatra Province is derived from the 150 kV interconnected system of Central Sumatra (West Sumatra, Jambi, Riau) as shown in Figure 5.1.3 through 14 substation with total capacity of 564.5 MVA and peak load of 328 MW.



Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

Figure 5.1.3 Power System in West Sumatra Province

From the main power sources, the following five power stations as listed in Table 5.1.7 with a total installed capacity of 473.8 MW are directly connected with 150 kV and 20 kV transmission systems.

Table 5.1.7 Existing Power Stations in West Sumatra Province

Name	Type	Owner	Installed Capacity (MW)
Ombilin	Coal-fired	PLN	200
Pauh Limo	Gas-fired (HSD)	PLN	64.05
Maninjau	Hydro	PLN	68
Singkarak	Hydro	PLN	131.25
Batang Agam	Hydro	PLN	10.5
Total			473.8

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

With total installed capacity of 473.8 MW and peak load of 328 MW, West Sumatra Province is able to meet its own needs during the rainy season and can even supply electricity of ±150 MW to Riau Provincem. During the dry season, however, West Sumatra Province needs to get additional power of ±100 MW from the southern part of Sumatra.

2) Future forecast

As shown in Table 5.1.8, RUPTL 2010-2019 forecasts future electricity sales and production as well as peak load in West Sumatra Province.

Table 5.1.8 Forecast of Electricity Sales, Production and Peak Load in West Sumatra Province

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sales	TWh	2.21	2.37	2.55	2.78	3.08	3.43	3.79	4.15	4.51	4.84
Production	TWh	2.36	2.53	2.72	2.96	3.29	3.67	4.06	4.44	4.83	5.24
Peak Load	MW	386	413	442	480	532	591	651	711	771	835

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

The primary energy sources which are ample in the West Sumatra Province are coal, geothermal and hydro. Sources of coals are spreading out in the City of Sawahlunto, and the Districts of Sijunjung, Pesisir Selatan, Solok, Limapuluh Kota and Solok Selatan. There is high potential for geothermal in the Districts of Solok Selatan and Solok. Meanwhile, potential for hydropower development is spread out in the entire province.

In order to serve the power demand up to 2019, PLN plans to increase the generating capacity of to a total of 670 MW by 2019. Such will be connected directly to the 150 kV and 20 kV transmission systems as shown in Table 5.1.9.

Table 5.1.9 Generation Expansion Plan in West Sumatra Province

Project Name	Owner	Type	Installed Capacity (MW)	COD	Status
Sumbar Pesisir	PLN	Coal	2x 112	2012	On-going
G. Talang	Private	Geothermal	20	2018	On-going
Muara Laboh	Private	Geothermal	2x 110	2014	Planned
Sumbar-1	Private	Coal	2x 100	2015	Planned
Mentawai	PLN	Coal	2x 3	2012	Planned
Total			670		

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

Furthermore, the PLN regional office for West Sumatra is cooperating with the local government and private sectors for the development of small-scale hydroelectric power plants as shown in Table 5.1.10.

Table 5.1.10 Planned Small-Scale Hydroelectric Power Plants in West Sumatra Province

Project Name	Owner	Type	Installed Capacity (MW)	Status
Manggani	Private	Small hydro	1.116	On-going
Gumanti	Private	Small hydro	2x 5	MoU
Sinamar	Private	Small hydro	2x 5	MoU
Lubuk Gadang	Private	Small hydro	4	MoU
Guning Tujuh	Private	Small hydro	2x 4	MoU
Tarusan	Private	Small hydro	3	MoU
Bayang	Private	Small hydro	2x 3	MoU
Muara Sako	Private	Small hydro	2.5	MoU
Sumpur	Private	Small hydro	2	MoU
Kambahan	Private	Small hydro	1.5	MoU
Fatimah	Private	Small hydro	1.4	MoU
Sikarban	Private	Small hydro	1.4	MoU
Guntung	Private	Small hydro	0.644	MoU
Total			51.56	

Source: Rencana Usaha Penyediaan Tenaga Listrik 2010-2019 by PLN

5.2 Availability of Surplus Water for Hydroelectric Power Generation

5.2.1 Original Design Discharge

As shown in Table 5.2.1, Diversion water requirement for irrigation in the original design is presented in "Engineering Report -Hydrology- for the Batang Hari Irrigation Project April 1995".

Table 5.2.1 Diversion Water Requirement for Irrigation

Unit: L/s/ha

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1st half	1.46	0.96	1.11	0.98	1.23	1.37	0.63	0.11	0.05	0.94	1.28	1.65
2nd half	1.27	1.58	1.57	1.50	1.60	1.16	0.42	0.15	0.00	0.84	1.42	1.02

Source: Engineering Report -Hydrology- April 1995

The figures in the upper row of the table above show the diversion water requirements in the first half of respective months. Meanwhile figures in the lower row show the ones in the second half. The peak diversion water requirement is estimated at 1.65 L/s/ha in the first half of December and this is defined as the design unit diversion water requirement.

The Batang Hari Irrigation System consists of four irrigation systems which are independently operated; Batang Hari main, Mimpi, Palangko Piruko and Siat irrigation systems. The command areas for irrigation of each system in the original design are as shown in Table 5.2.2.

Table 5.2.2 Command Area for Irrigation

Irrigation System	Command Area (ha)
Batang Hari main	15,271
Mimpi	295
Palangko Piruko	725
Siat	2,645
Total	18,936

Source: Engineering Report -Hydrology- April 1995

The Batang Hari main irrigation system is the core component of the Batang Hari Irrigation System, where the possibility of micro hydroelectric power generation is examined. Taking into account its command area (15,271 ha), the required discharge for irrigation in the Batang Hari main irrigation area based on the original design is calculated as shown in Table 5.2.3.

Table 5.2.3 Required Discharge for Irrigation

Unit: m^3/s

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1st half	22.3	14.7	17.0	15.0	18.8	20.9	9.6	1.7	0.8	14.4	19.5	25.2
2nd half	19.4	24.1	24.0	22.9	24.4	17.7	6.4	2.3	0.0	12.8	21.7	15.6

Source: JICA Survey Team

5.2.2 Current Situation of Irrigation Water Use

According to *Balai Wilayah Sungai* (BWS) Sumatra VI, the existing areas of irrigation and fishpond within the command area of Batang Hari main irrigation system as of June, 2011 are 5,137 ha and 257 ha, respectively. Taking into account the unit water requirements, 1.65 L/s/ha for irrigation and 12.00 L/s/ha for fishpond, the required discharge for both irrigation and fishpond in the Batang Hari main irrigation command area at its current condition was calculated at 11.56 m^3/s as shown below.

Irrigation	:	5,137 ha	×	1.65 L/s/ha	=	8.48 m^3/s
Fishpond	:	257 ha	×	12.00 L/s/ha	=	3.08 m^3/s
Total						11.56 m^3/s

5.2.3 Current Operation of Irrigation System

The basic concept in the original design for the distribution of irrigation water to respective command areas is to always operate the headrace and the main canal under the peak water requirement (25.2 m^3/s for the headrace channel) and adjust the discharge to secondary canals by rotation which can be performed by an on-off operation of the secondary canal gate at diversion structures.

Table 5.2.4 shows records of the water intake discharge at the Batang Hari weir from March to August, 2011. The average water intake during these six months is 19.9 m^3/s.

Table 5.2.4 Water Intake Discharge at Batang Hari Weir in 2011

Unit: m^3/s

	Mar.	Apr.	May	Jun.	Jul.	Aug.
1st half	18.1	16.9	17.4	21.0	22.5	21.9
2nd half	18.0	17.7	18.1	22.6	22.7	22.2

Source: Balai Wilayah Sungai (BWS) VI

5.2.4 Future Irrigation Water Utilization Plans

In June 2010, DGWR of MPW and Dharmasraya District concluded a Minutes of Understanding (MoU) that considers additional water use in 2011-2014 for the following:

- New irrigation area of 2,000 ha;
- New fishpond of 443 ha; and

- New water use for drinking water of 120 L/sec.

Taking into account the existing areas of irrigation and fishpond within the Batang Hari main irrigation area, the total required discharge for irrigation, fishpond and drinking water use in the Batang Hari main irrigation system as of 2014 is calculated, as shown below, at 20.30 m^3/s.

Existing						
Irrigation	:	5,137 ha	×	1.65 L/s/ha	=	8.48 m^3/s
Fishpond	:	257 ha	×	12.00 L/s/ha	=	3.08 m^3/s
Sub-total						11.56 m^3/s
MoU						
Irrigation		2,000 ha	×	1.65 L/s/ha	=	3.30 m^3/s
Fishpond		443 ha	×	12.00 L/s/ha	=	5.32 m^3/s
Drinking Water						0.12 m^3/s
Sub-total						8.74 m^3/s
Total						20.30 m^3/s

5.2.5 Water Availability for Micro Hydroelectric Power Generation

In the Batang Hari main irrigation system, there are several sites considered for the possibility of micro hydroelectric power generation. They are categorized into the following three types:

- Usage of surplus water in the main canal;
- Usage of drop works, diversion works and siphons; and
- Usage of headworks.

(1) Usage of Surplus Water in Main Canal

This plan diverts surplus water that was not used for irrigation or for any purpose from the main canal to the river. The amount of surplus water available is determined by the following conditions:

- Water intake discharge at the Batang Hari headworks;
- Required discharge for irrigation, fishpond and drinking water; and
- Discharge capacity of the main canal.

1) Water intake discharge at Batang Hari Headworks

The maximum design intake discharge at the Batang Hari headworks is set at 30.2 m^3/s, and the design discharge for the headrace channel of the Batang Hari main irrigation system is set at 25.2 m^3/s throughout a year except during the maintenance period of the headrace and main canals.

The maintenance period of the headrace and the main canal was assumed to be 15 days in the second half of every September. During that period, it was assumed that there is no water is available in the main canal.

2) Required discharge for irrigation, fishpond and drinking water

The required discharge for irrigation, fishpond and drinking water is counted for upstream and downstream of the diverting point for power generation. The values in case that BBH6 is the diverting point are calculated for both the basic and alternative scenarios as shown below..

Basic Scenario

Water requirement assumed in the original design is considered as the basic scenario.

Upstream (U/S) of BBH6						
Irrigation	:	2,209 ha	×	1.65 L/s/ha	=	3.64 m^3/s
Downstream (D/S) of BBH6						
Irrigation		13,062 ha	×	1.65 L/s/ha	=	21.56 m^3/s
Total						25.20 m^3/s

Alternative Scenario

Water requirement assumed in the existing condition and MoU (2011-2014) is considered as the alternative scenario.

U/S of BBH6						
Irrigation	:	1,819 ha	×	1.65 L/s/ha	=	3.00 m^3/s
Fishpond	:	105 ha	×	12.00 L/s/ha	=	1.26 m^3/s
Drinking Water						0.00 m^3/s
Sub-total						4.26 m^3/s
D/S of BBH6						
Irrigation		5,318 ha	×	1.65 L/s/ha	=	8.78 m^3/s
Fishpond		595 ha	×	12.00 L/s/ha	=	7.14 m^3/s
Drinking Water						0.12 m^3/s
Sub-total						16.04 m^3/s
Total						20.30 m^3/s

3) Discharge Capacity of Main Canal

The discharge capacity of the main canal at the immediate upstream of the diverting point for power generation is also a constraint condition. According to the “Design Report of Irrigation and Drainage System for the Batang Hari Irrigation Project, May 1996”, the discharge capacity of the main canal at the immediate upstream of BBH6 is 21.55 m^3/s.

Based on the conditions 1), 2) and 3) above, surplus water available for power generation is calculated for both the basic and alternative scenarios. Summary of the calculation is as shown in Table 5.2.5. The annual average discharge is 7.43 m^3/s for the basic scenario and 8.19 m^3/s for the alternative scenario.

Table 5.2.5 Surplus Water Available for Power Generation at BBH6 Site

Basic Scenario Unit: m^3/s

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1st half	2.48	9.01	7.05	8.75	5.48	3.66	13.32	20.11	20.90	9.27	4.83	0.00
2nd half	4.96	0.91	1.04	1.96	0.65	6.40	16.06	19.59	0.00	10.58	3.00	8.23

Alternative Scenario Unit: m^3/s

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1st half	6.26	9.18	8.39	9.08	7.75	6.90	10.94	13.71	14.02	9.29	7.48	4.90
2nd half	7.54	5.40	5.47	5.97	5.26	8.12	12.06	13.49	0.00	9.82	6.55	8.87

Source: JICA Survey Team

Details of calculation to obtain the above are shown in Tables 5.2.6 and 5.2.7.

Table 5.2.6 Surplus Water Available for Power Generation (Basic Scenario)

Headrace Channel (U/S of BBH1)		
Design discharge	m3/s	25.20
Command area for irrigation	ha	15,271
Main Canal (U/S of BBh6)		
Design discharge	m3/s	21.55
Command area for irrigation	ha	13,062
BBH1-BBH6		
Command area for irrigation	ha	2,209

	Diversion Water Requirement	Required Discharge for BBH1-BBH6	Discharge in case of Max. Intake U/S of BBH6	Required Discharge for D/S of BBH6	Surplus Water in case of Max. Intake BBH6	Surplus Water in case of Maintenance BBH6	Surplus Water Descending Order BBH6
	l/s/ha	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s
Jan.	1.46	3.23	21.55	19.07	2.48	2.48	20.90
	1.27	2.81	21.55	16.59	4.96	4.96	20.11
Feb.	0.96	2.12	21.55	12.54	9.01	9.01	19.59
	1.58	3.49	21.55	20.64	0.91	0.91	16.06
Mar.	1.11	2.45	21.55	14.50	7.05	7.05	13.32
	1.57	3.47	21.55	20.51	1.04	1.04	10.58
Apr.	0.98	2.16	21.55	12.80	8.75	8.75	9.27
	1.50	3.31	21.55	19.59	1.96	1.96	9.01
May	1.23	2.72	21.55	16.07	5.48	5.48	8.75
	1.60	3.53	21.55	20.90	0.65	0.65	8.23
Jun.	1.37	3.03	21.55	17.89	3.66	3.66	7.05
	1.16	2.56	21.55	15.15	6.40	6.40	6.40
Jul.	0.63	1.39	21.55	8.23	13.32	13.32	5.48
	0.42	0.93	21.55	5.49	16.06	16.06	4.96
Aug.	0.11	0.24	21.55	1.44	20.11	20.11	4.83
	0.15	0.33	21.55	1.96	19.59	19.59	3.66
Sep.	0.05	0.11	21.55	0.65	20.90	20.90	3.00
	0.00	0.00	21.55	0.00	21.55	0.00	2.48
Oct.	0.94	2.08	21.55	12.28	9.27	9.27	1.96
	0.84	1.86	21.55	10.97	10.58	10.58	1.04
Nov.	1.28	2.83	21.55	16.72	4.83	4.83	0.91
	1.42	3.14	21.55	18.55	3.00	3.00	0.65
Dec.	1.65	3.64	21.55	21.55	0.00	0.00	0.00
	1.02	2.25	21.55	13.32	8.23	8.23	0.00
Ave.						7.43	7.43

Source: JICA Survey Team

Table 5.2.7 Surplus Water Available for Power Generation (Alternative Scenaio)

Headrace Channel (U/S of BBH1)		
Design discharge	m3/s	25.20
Command area for irrigation	ha	7,137
Command area for fishpond	ha	700
Required discharge for drinking water	m3/s	0.12
Main Canal (U/S of BBH6)		
Design discharge	m3/s	21.55
Command area for irrigation	ha	5,318
Command area for fishpond	ha	595
Required discharge for drinking water	m3/s	0.12
BBH1-BBH6		
Command area for irrigation	ha	1,819
Command area for fishpond	ha	105
Required discharge for drinking water	m3/s	0.00

	Diversion Water Requirement for Irrigation	Diversion Water Requirement for Fishpond	Required Discharge for Irrigation BBH1-BBH6	Required Discharge for Fishpond BBH1-BBH6	Required Discharge for Drinking BBH1-BBH6	Total BBH1-BBH6	Discharge in case of Max. Intake U/S of BBH6	Required Discharge for Irrigation D/S of BBH6	Required Discharge for Fishpond D/S of BBH6	Required Discharge for Drinking D/S of BBH6	Total D/S of BBH6	Surplus Water in case of Max. Intake BBH6	Surplus Water in case of Maintenance BBH6	Surplus Water Descending Order BBH6
	l/s/ha	l/s/ha	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s
Jan.	1.46	12.00	2.66	1.26	0.00	3.92	21.28	7.76	7.14	0.12	15.02	6.26	6.26	14.02
	1.27	12.00	2.31	1.26	0.00	3.57	21.55	6.75	7.14	0.12	14.01	7.54	7.54	13.71
Feb.	0.96	12.00	1.75	1.26	0.00	3.01	21.55	5.11	7.14	0.12	12.37	9.18	9.18	13.49
	1.58	12.00	2.87	1.26	0.00	4.13	21.07	8.40	7.14	0.12	15.66	5.40	5.40	12.06
Mar.	1.11	12.00	2.02	1.26	0.00	3.28	21.55	5.90	7.14	0.12	13.16	8.39	8.39	10.94
	1.57	12.00	2.86	1.26	0.00	4.12	21.08	8.35	7.14	0.12	15.61	5.47	5.47	9.82
Apr.	0.98	12.00	1.78	1.26	0.00	3.04	21.55	5.21	7.14	0.12	12.47	9.08	9.08	9.29
	1.50	12.00	2.73	1.26	0.00	3.99	21.21	7.98	7.14	0.12	15.24	5.97	5.97	9.18
May	1.23	12.00	2.24	1.26	0.00	3.50	21.55	6.54	7.14	0.12	13.80	7.75	7.75	9.08
	1.60	12.00	2.91	1.26	0.00	4.17	21.03	8.51	7.14	0.12	15.77	5.26	5.26	8.87
Jun.	1.37	12.00	2.49	1.26	0.00	3.75	21.45	7.29	7.14	0.12	14.55	6.90	6.90	8.39
	1.16	12.00	2.11	1.26	0.00	3.37	21.55	6.17	7.14	0.12	13.43	8.12	8.12	8.12
Jul.	0.63	12.00	1.15	1.26	0.00	2.41	21.55	3.35	7.14	0.12	10.61	10.94	10.94	7.75
	0.42	12.00	0.76	1.26	0.00	2.02	21.55	2.23	7.14	0.12	9.49	12.06	12.06	7.54
Aug.	0.11	12.00	0.20	1.26	0.00	1.46	21.55	0.58	7.14	0.12	7.84	13.71	13.71	7.48
	0.15	12.00	0.27	1.26	0.00	1.53	21.55	0.80	7.14	0.12	8.06	13.49	13.49	6.90
Sep.	0.05	12.00	0.09	1.26	0.00	1.35	21.55	0.27	7.14	0.12	7.53	14.02	14.02	6.55
	0.00	12.00	0.00	1.26	0.00	1.26	21.55	0.00	7.14	0.12	7.26	14.29	0.00	6.26
Oct.	0.94	12.00	1.71	1.26	0.00	2.97	21.55	5.00	7.14	0.12	12.26	9.29	9.29	5.97
	0.84	12.00	1.53	1.26	0.00	2.79	21.55	4.47	7.14	0.12	11.73	9.82	9.82	5.47
Nov.	1.28	12.00	2.33	1.26	0.00	3.59	21.55	6.81	7.14	0.12	14.07	7.48	7.48	5.40
	1.42	12.00	2.58	1.26	0.00	3.84	21.36	7.55	7.14	0.12	14.81	6.55	6.55	5.26
Dec.	1.65	12.00	3.00	1.26	0.00	4.26	20.94	8.77	7.14	0.12	16.03	4.90	4.90	4.90
	1.02	12.00	1.86	1.26	0.00	3.12	21.55	5.42	7.14	0.12	12.68	8.87	8.87	0.00
Ave.													8.19	8.19

Source: JICA Survey Team

(2) Usage of Drop Works and Diversion Works

This plan utilizes the head at the drop works and diversion works in the main canal. The amount of discharge available in the main canal is determined by the same constraint conditions as the case of usage of surplus water in main canal.

(3) Usage of Headworks

This plan utilizes the head difference between the upstream and downstream of the Batang Hari headworks and the river run-off not taken for irrigation. The amount of run-off available is determined by the following conditions:

- Water intake discharge at the Batang Hari headworks; and
- River run-off of the Batang Hari River.

1) Water intake discharge at Batang Hari headworks

Similar with the case of usage of surplus water in main canal, water intake discharge at the Batang Hari headworks is set at 25.2 m^3/s throughout the year, except during the maintenance period of 15 days in the second half of every September.

2) River run-off of the Batang Hari River

The river run-off records of the Batang Hari River are presented in the "Engineering Report -Hydrology- for the Batang Hari Irrigation Project April 1995". According to this, the monthly mean run-off at Sungai Dareh Gauging Station on the Batang Hari River from 1975 to 1993 is as shown in Table 5.2.8..

Table 5.2.8 Monthly Mean Run-off of Batang Hari River at Sungai Dareh Gauging Station

Unit: m^3/s

	Jan.	**Feb.**	**Mar.**	**Apr.**	**May.**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Ave.	412.2	320.2	408.3	443.2	366.9	247.2	208.3	178.3	191.8	237.8	417.0	369.3
Max.	586.0	481.8	708.1	631.6	561.4	414.3	297.7	225.7	282.1	373.1	770.9	535.4
Min.	201.0	155.0	261.5	262.4	162.5	145.1	132.6	134.5	85.9	95.9	178.4	135.4

Source: Engineering Report -Hydrology- April 1995

The lowest average of monthly mean discharge is in August at 178.3 m^3/s, and the minimum monthly mean discharge is in September at 85.9 m^3/s.

Based on the above, run-off of 60 m^3/s (=85.9 – 25.2) might be considered as the available discharge for power generation.

5.3 Site Selection for Hydroelectric Power Generation

The Survey Team made preliminary examination on potential sites for micro hydroelectric power generation for schemes categorized in the following three types of planning:

- Power generation plan using surplus water in the main canal;
- Power generation plan using drop works, diversion works and siphons; and
- Power generation plan using headworks.

5.3.1 Power Generation Plan Using Surplus Water in Main Canal

The headrace channel has a capacity to take in the maximum irrigation requirement of 25.2 m^3/s and let it flow down. Surplus water that is not used for irrigation may be diverted from the main canal into the river and be used for power generation by utilizing the head created.

For this type of development, two plans are conceivable. One is utilization of the head between the main canal and the Batang Hari River. The other is utilization of the head between the aqueduct of the main canal and the river beneath the aqueduct.

(1) Utilization of Head between Main Canal and Batang Hari River

This idea is to utilize the existing idle pump station building which was constructed under the Sungai Dareh Sitiung Irrigation (SEDASI) Project and the Sitiung secondary canal for power generation purpose by rehabilitating these facilities and installing new turbines/generators. (1981-1991). (existing, but currently no used) that was rehabilitated and has newly installed

The SEDASI pump station had been operated from 1981. However, operations of the pump facilities were forced to be terminated due to insufficiency of spare-parts for the equipment soon after the project was completed in 1991.

The SEDASI pump station is located in Pisangrebus Village, about 1.7 km north of the diversion structure BBH7. As shown in Figure 5.3.1, the following are two alternatives conceivable for connecting the pump station with the Batang Hari main canal;

- BBH6 and the Sitiung secondary canal; or
- BBH7 and the old canal for pumping.

The Sitiung secondary canal was constructed under the Batang Hari Irrigation Project (1998-2008). Its function was to discharge irrigation water of 0.32 m^3/s from BBH6 to the command area of irrigation (191 ha). Although the design discharge is rather small, this canal has comparatively large sections which enable the discharge of the required quantity of water for power generation with a small degree of rehabilitation.

The old canal for pumping was constructed under the SEDASI project. Its function was to discharge pumped water (5 m^3/s) from the pump station to the main canal. Although the canal section is sufficiently large, there exists some check structures which were newly constructed under the Batang Hari Irrigation Project. These check structures should be demolished and removed in case this old canal is used for power generation. Furthermore, there exists an old aqueduct which crosses a deep valley, the details of which are unknown.

Based on the above situation, BBH6 and the Sitiung secondary canal seems more preferable for using as connection between the SEDASI pump station and the Batang Hari main canal.

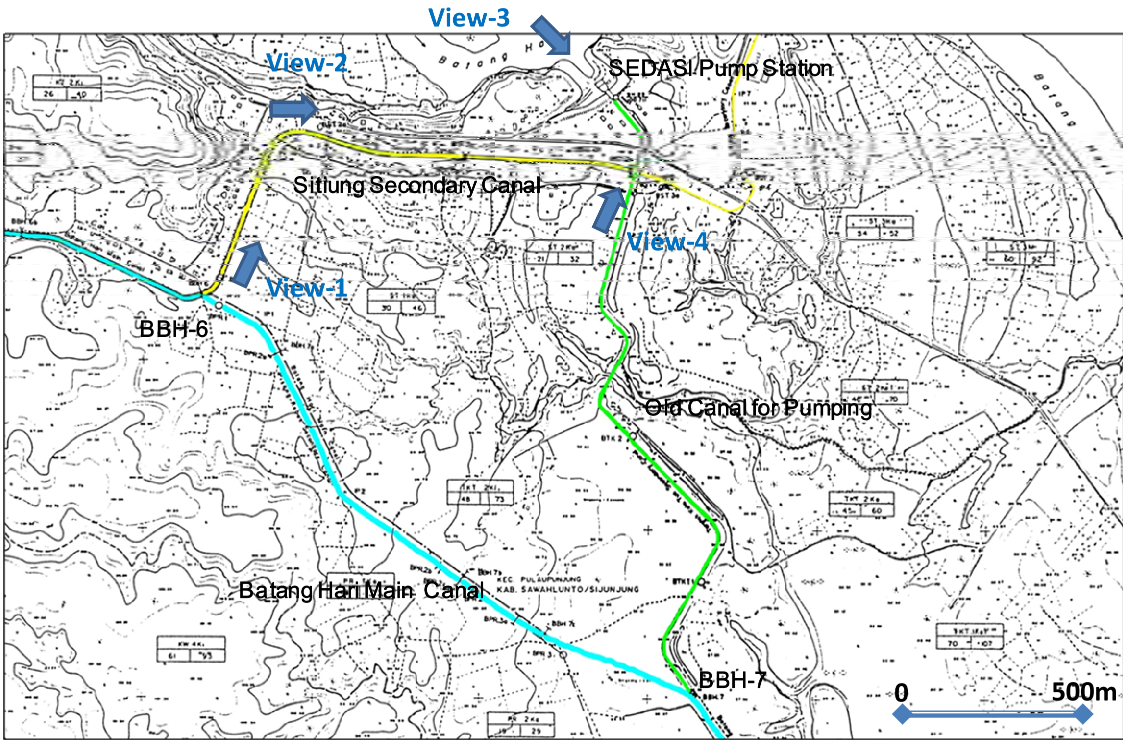


Figure 5.3.1 General Layout of SEDASI Pump Station and Batang Hari Main Canal

Figure 5.3.2 Sitiung Secondary Canal and Old Canal for Pumping

Figure 5.3.2 shows the current situation of the Sitiung secondary canal and the old canal for pumping. The length of the Sitiung secondary canal between the diversion structure BBH6 up to its junction with the old canal for pumping is about 1.55 km. The canal has a trapezoidal section without lining, and its bottom width is 3.0~5.5m (View-1 and View-2 of Figure 2.1.2).

The old canal for pumping is also partly used for power generation. The distance of which is about 0.3 km from its junction with the Sitiung secondary canal up to its end which is adjacent to the SEDASI pump station (View-3 of Figure 2.1.2). The canal has a trapezoidal section without lining, and its bottom width is 12.0m.

A check structure constructed in the Batang Hari Irrigation Project is seen in the old canal for pumping at the opposite side of the junction (View-4 of Figure 2.1.2). The crest of this structure controls the water level of the Sitiung secondary canal. Surplus water which overflows this crest is led to the existing spillway nearby the aqueduct and then discharged to the tributary beneath the aqueduct.

Figure 5.3.3 SEDASI Pump Station

Figure 5.3.3 shows the current situation of the SEDASI pump station. Six sets of pumps and motors as well as steel pipes had been installed under the SEDASI project. Some of the steel pipes which connect the canal and building have been already removed by BWS VI for other usage. The superstructure of the building, including the roof and windows, are damaged, however, the substructure of the building seems to be still sound. Figure 5.3.4 shows the plan and profile of the SEDASI pump station.

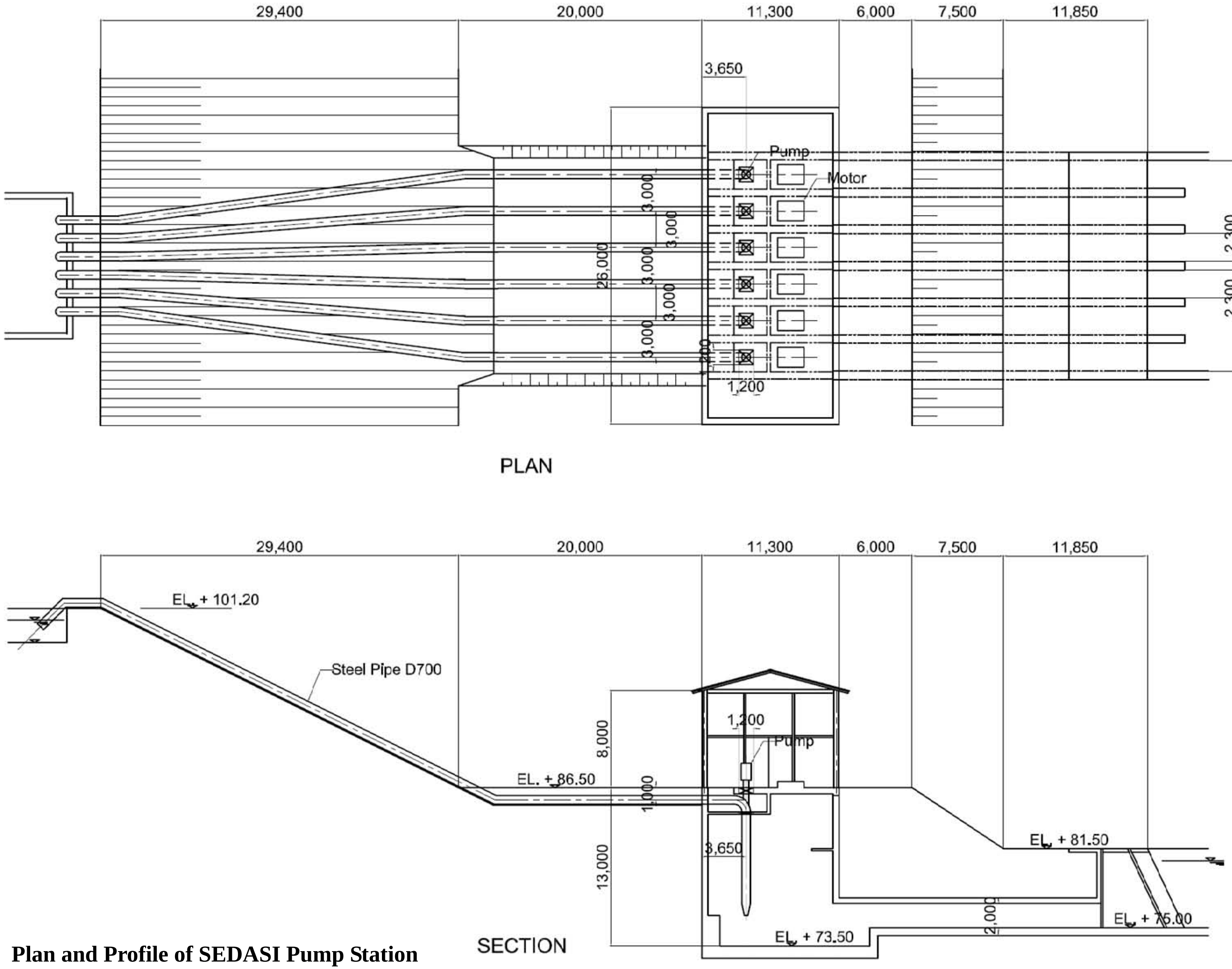


Figure 5.3.4 Plan and Profile of SEDASI Pump Station

Source: JICA Survey Team