OPTIMAL WATER SHARING FOR SUSTAINABLE WATER RESOURCE UTILIZATION

IN CICATIH-CIMANDIRI WATERSHED SUKABUMI, INDONESIA

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INTRODUCTION

- Effective water management in agriculture is crucial not only for supplying water in a right volume and time but also to make sure that the water is readily available for other water users for long times.
- This paper proposes a concept of optimum water sharing to find a robust agricultural water management for sustainable development of rice production.
- We present a case study to introduce the concept of optimum water sharing in Cicatih-Cimandiri watershed in Sukabumi, West-Java.

CICATIH-CIMANDIRI WATERSHED

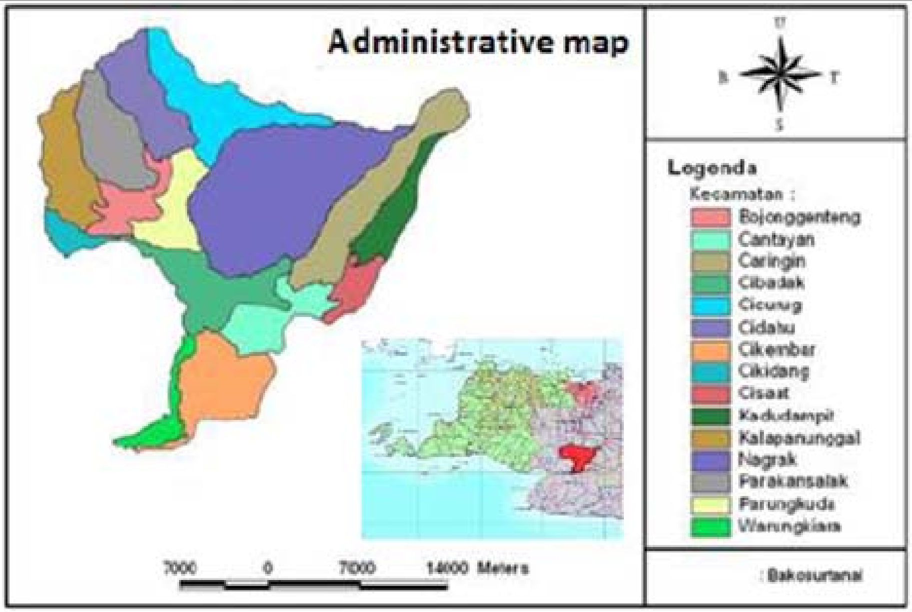


Figure 1 Districts (15) in Cicatih-Cimandiri Watershed of Sukabumi Regency

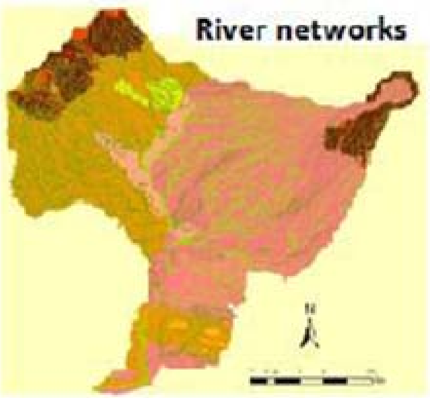
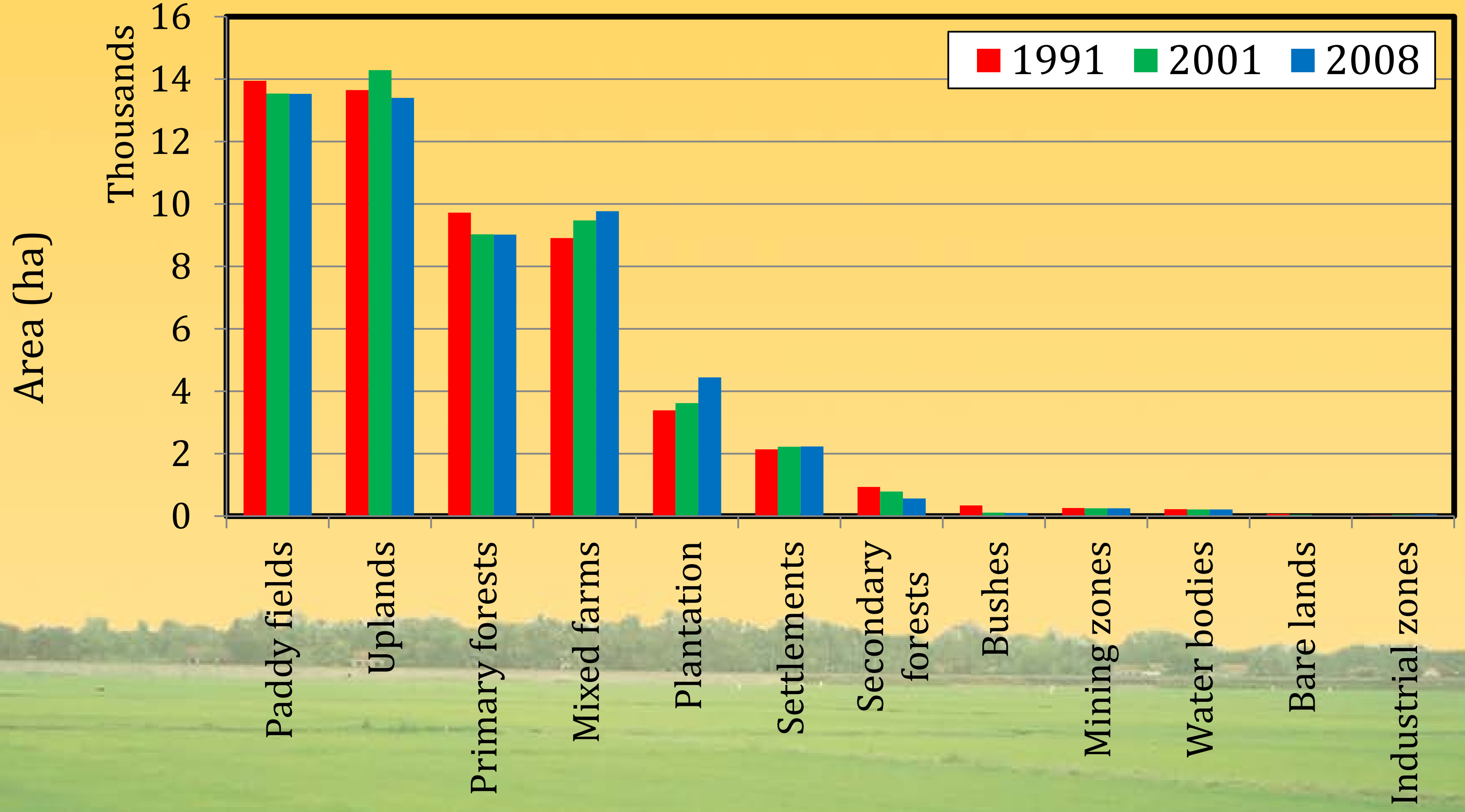


Figure 2 Sub-watersheds (5) and river networks

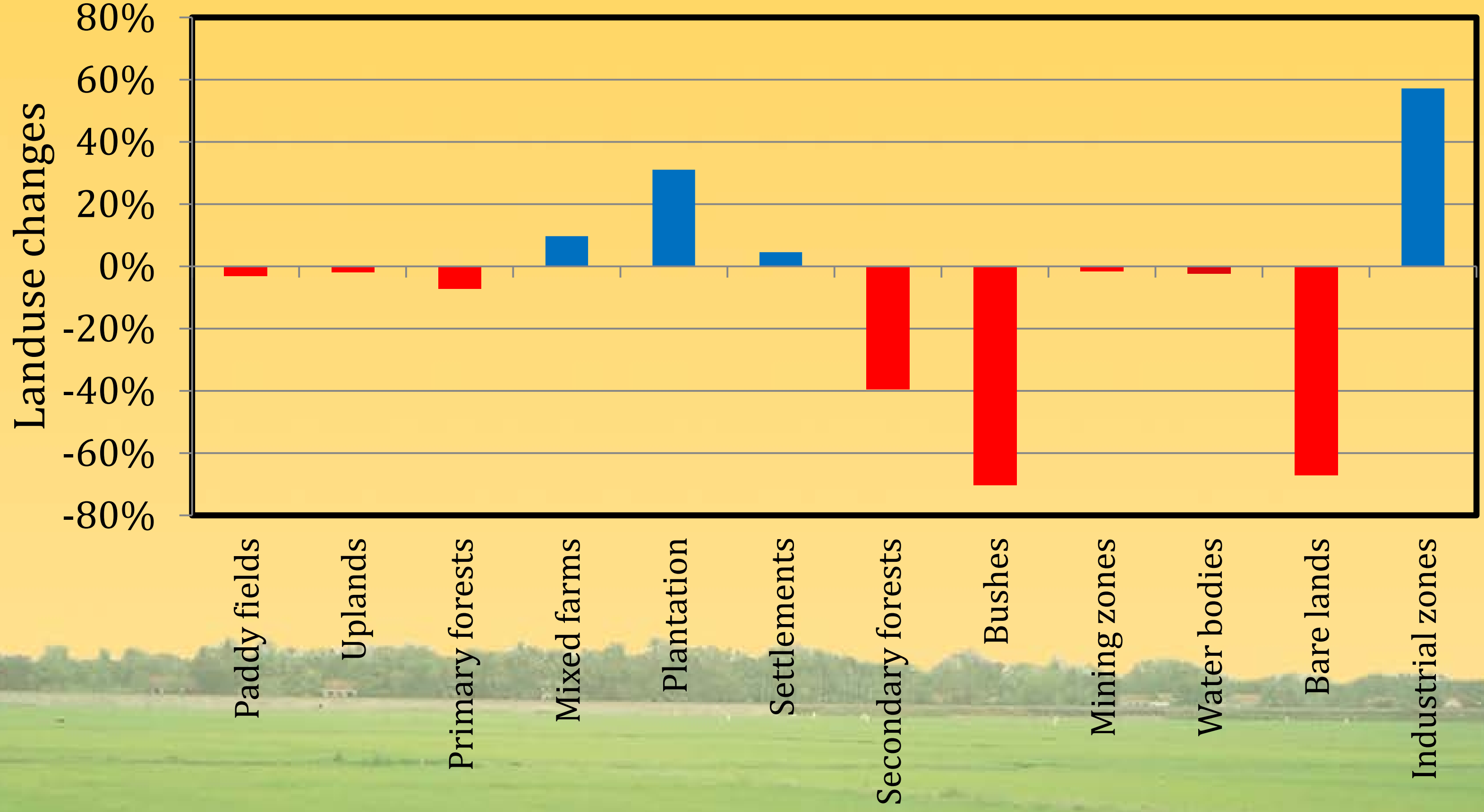
Table 1 Sub-watersheds and their areas

No	Sub-watershed	Area (ha)	Fraction
1	Cicatih Hulu	9,939	19%
2	Cipalasari	9,306	18%
3	Ciheulang	15,911	30%
4	Cileuleuy	9,234	17%
5	Cikembar	8,589	16%
	Total	52,979	

LAND USES & COVERS 1991-2008

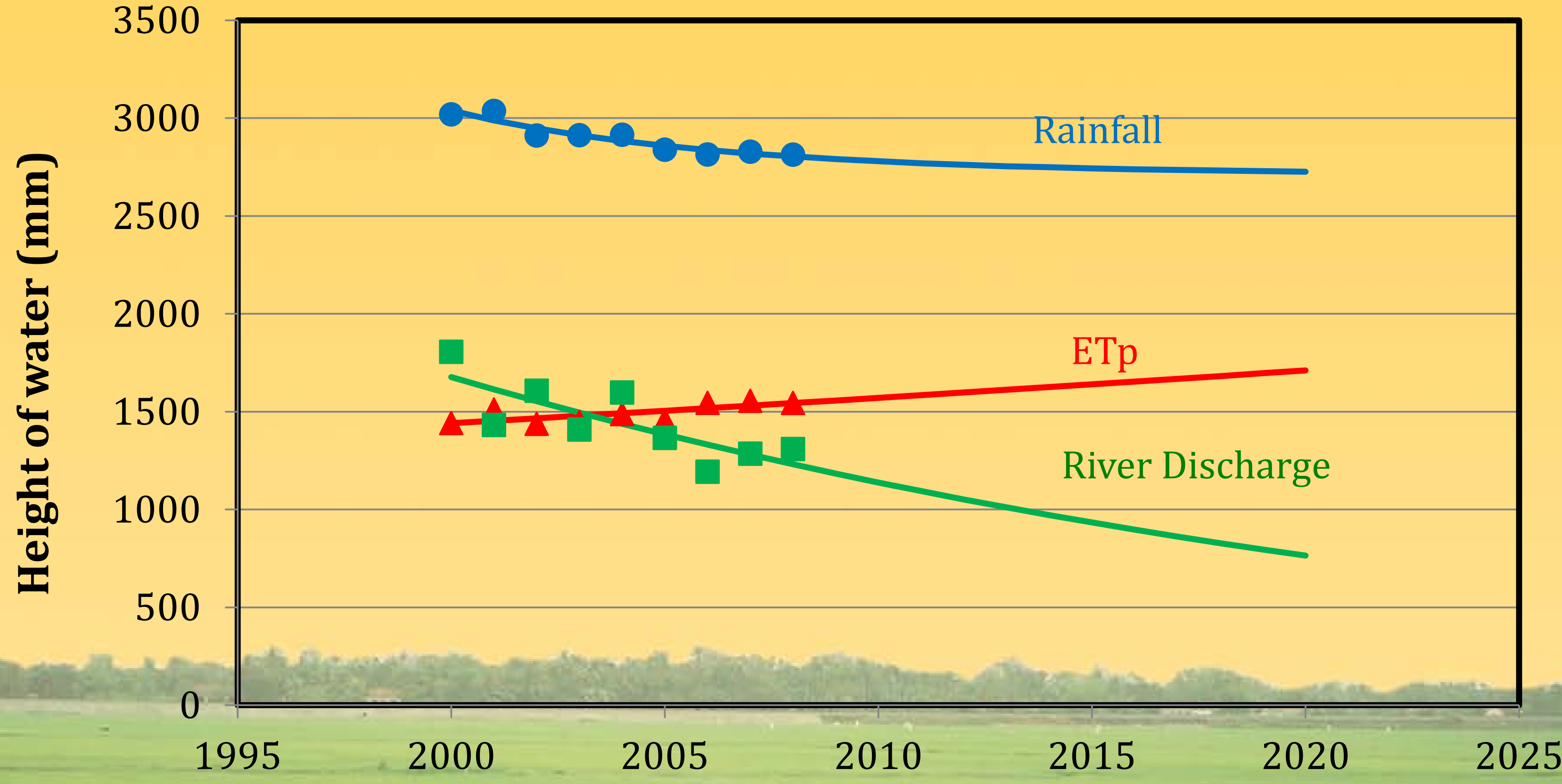


LANDUSE CHANGES 1991-2008

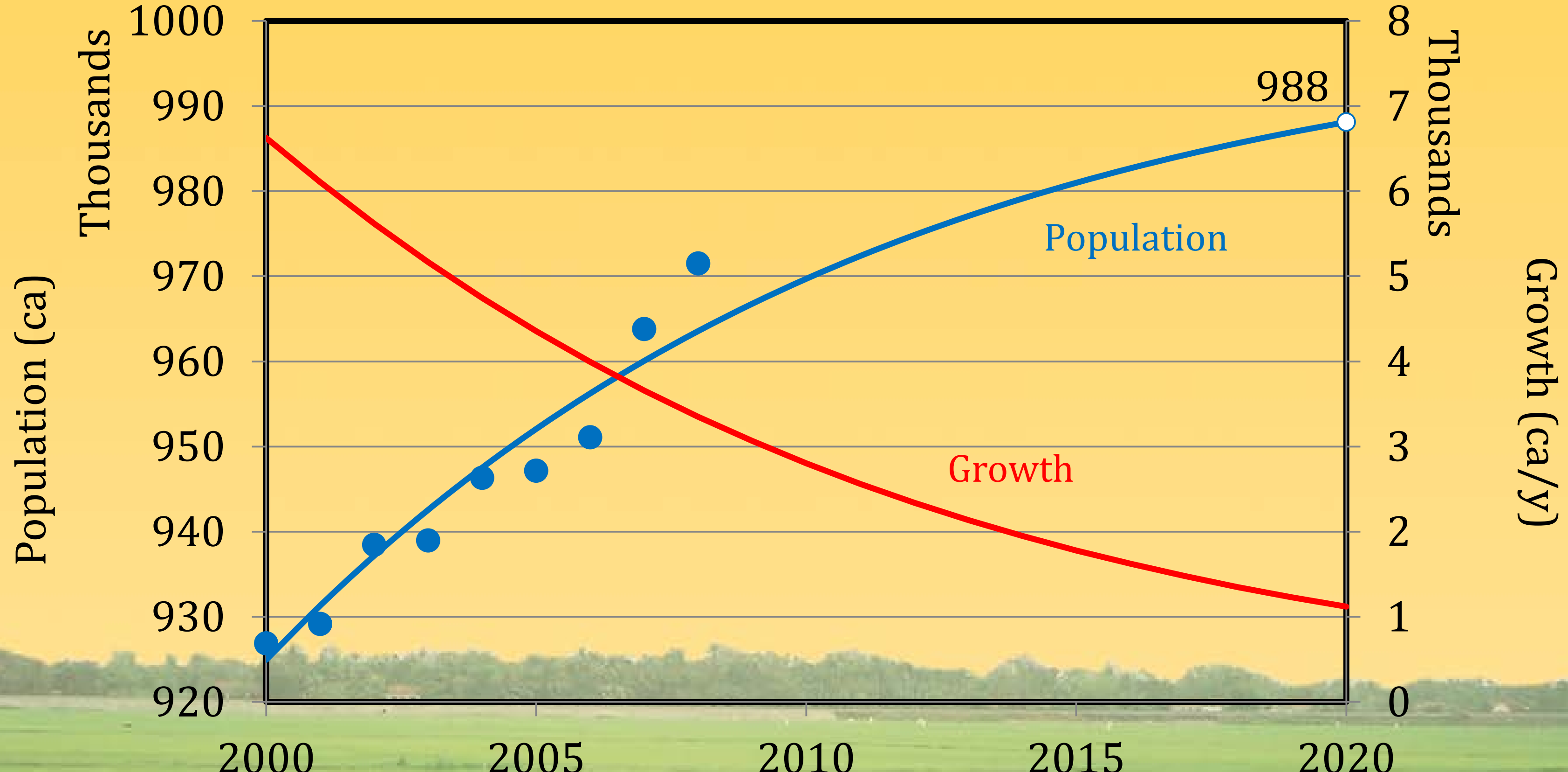


HYDROLOGY

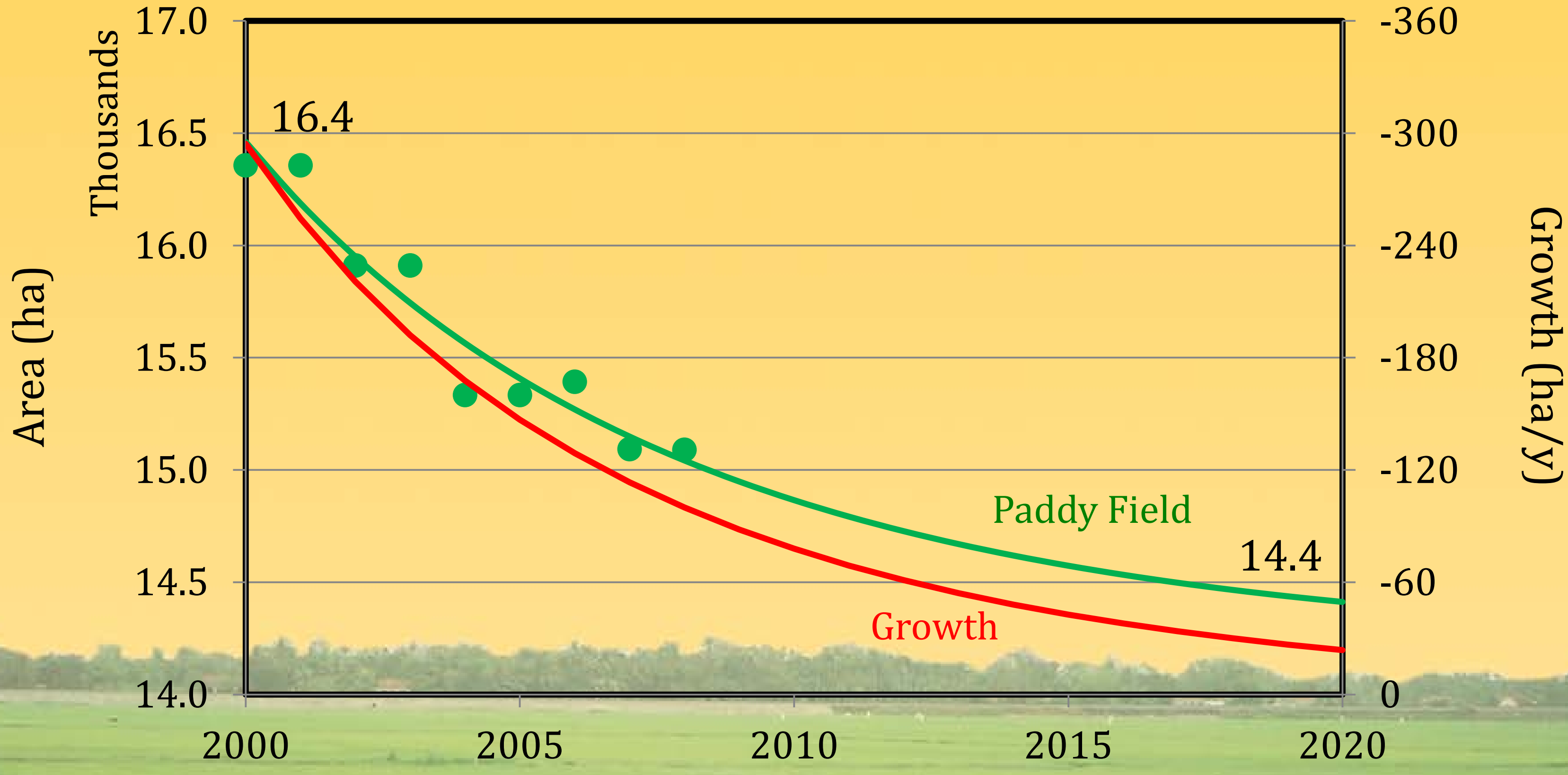
Rainfall, Evapotranspiration & Dicharges



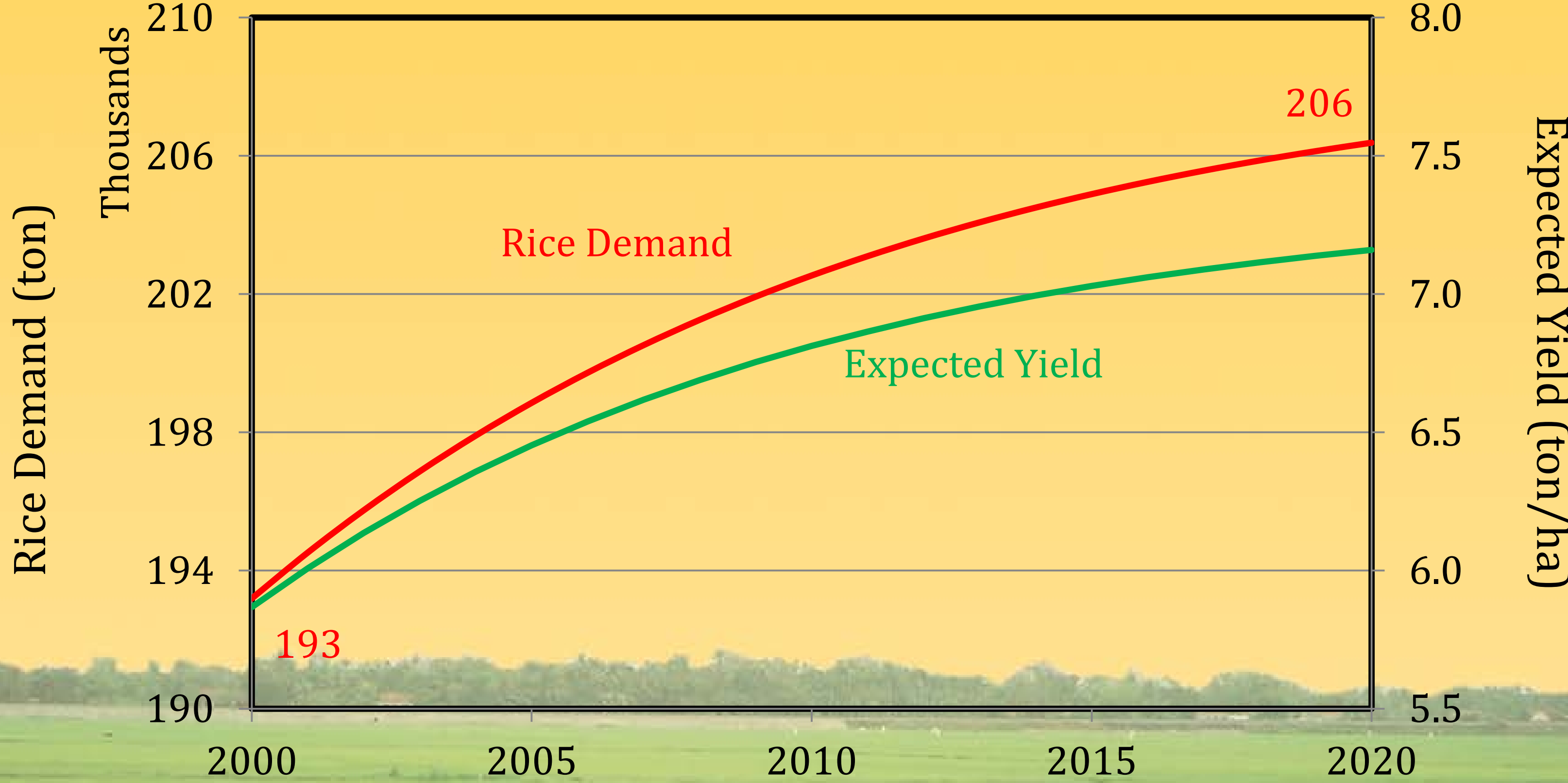
POPULATION AND ITS GROWTH



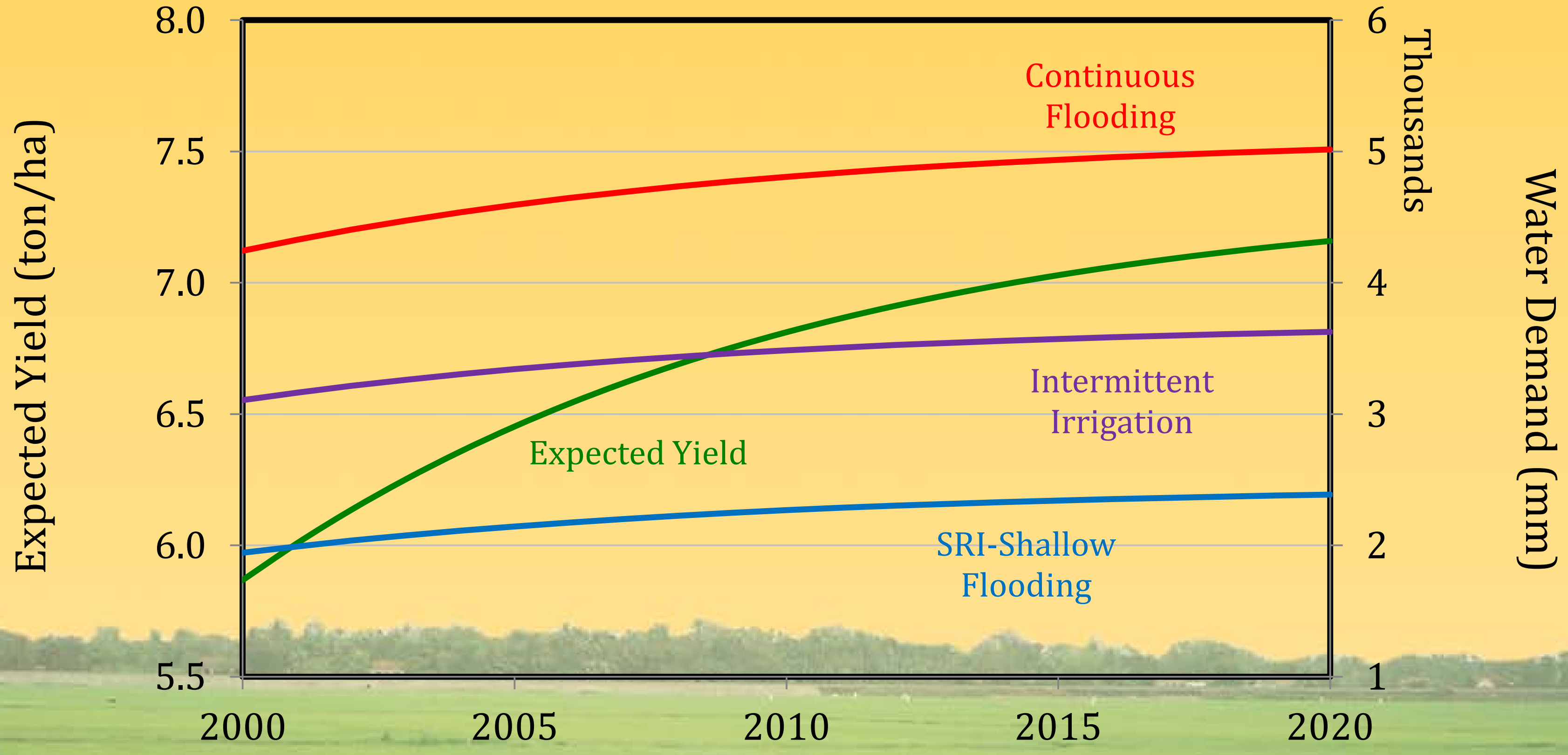
PADDY FIELD AND ITS GROWTH



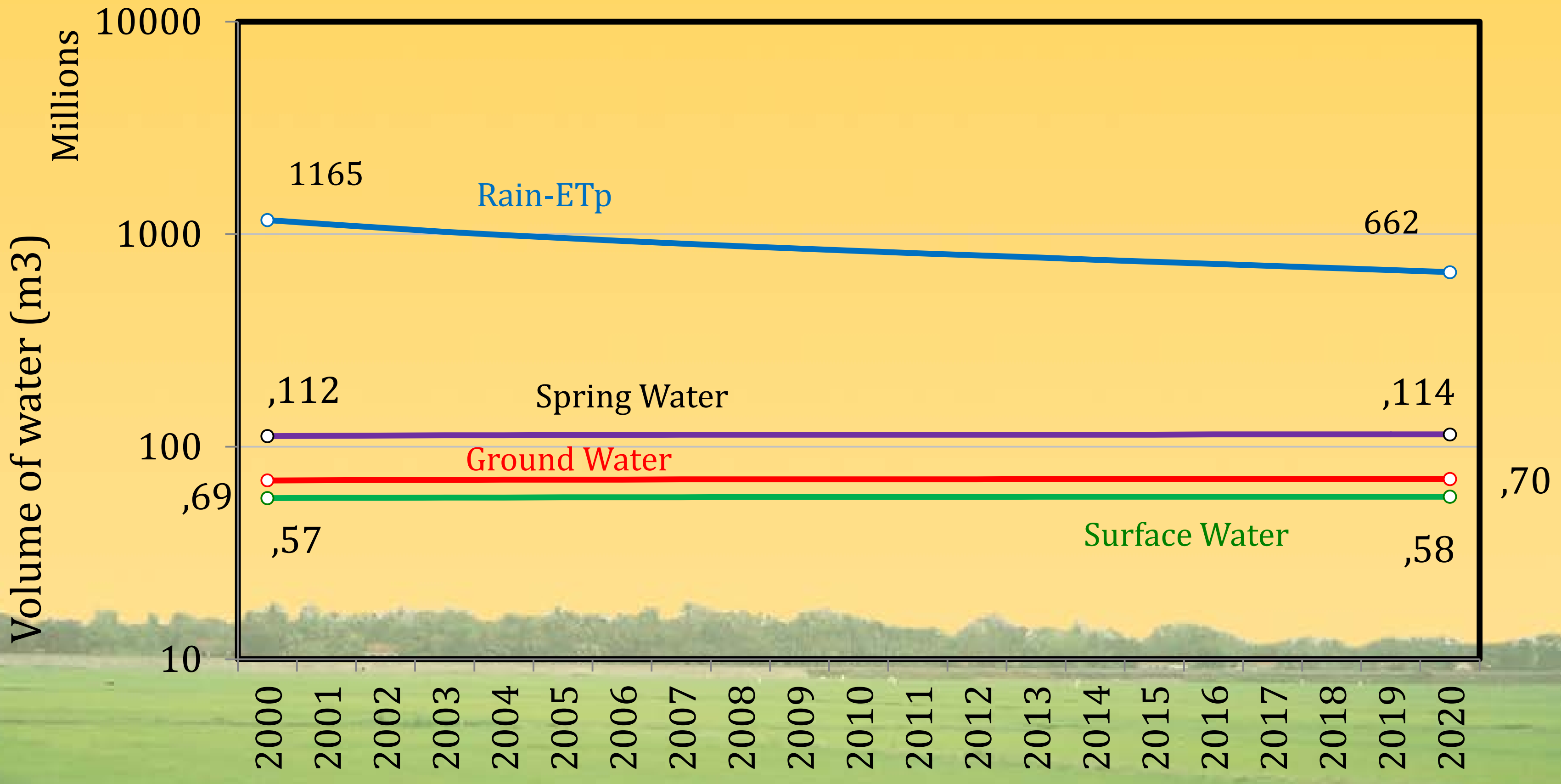
RICE DEMAND AND EXPECTED YIELD



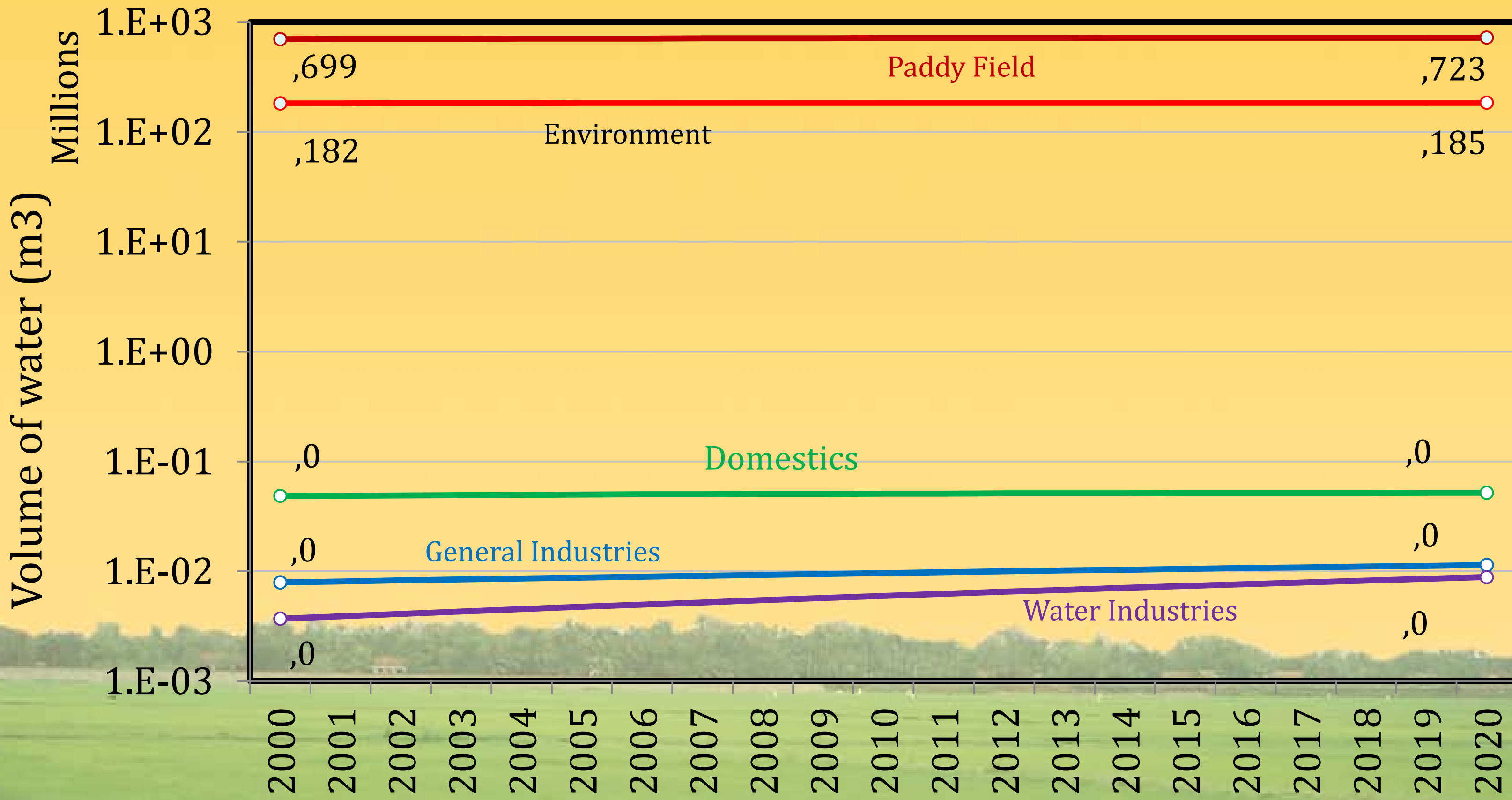
EXPECTED YIELD AND WATER DEMAND (2 Seasons)



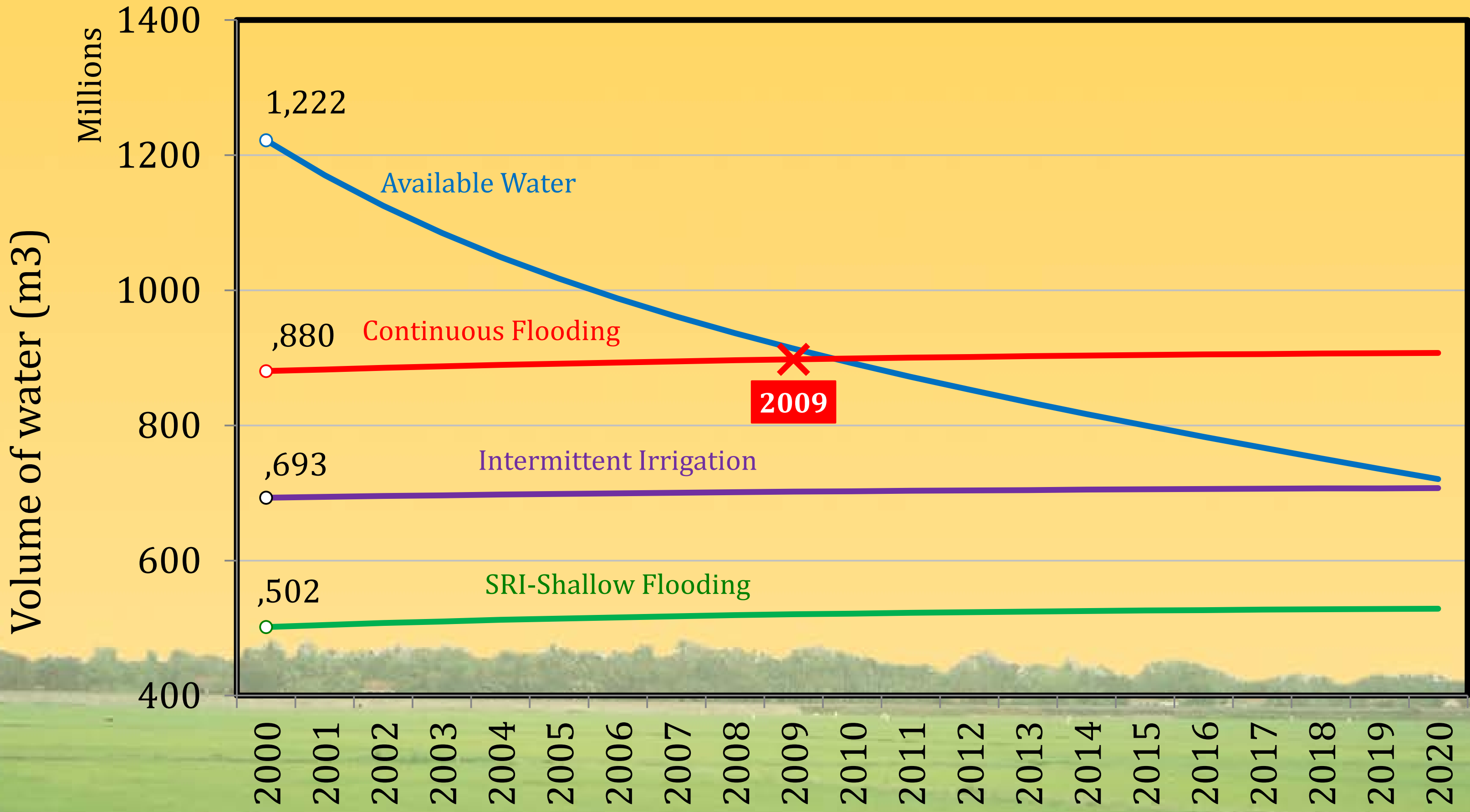
AVAILABLE WATER RESOURCES



OVERALL WATER DEMANDS

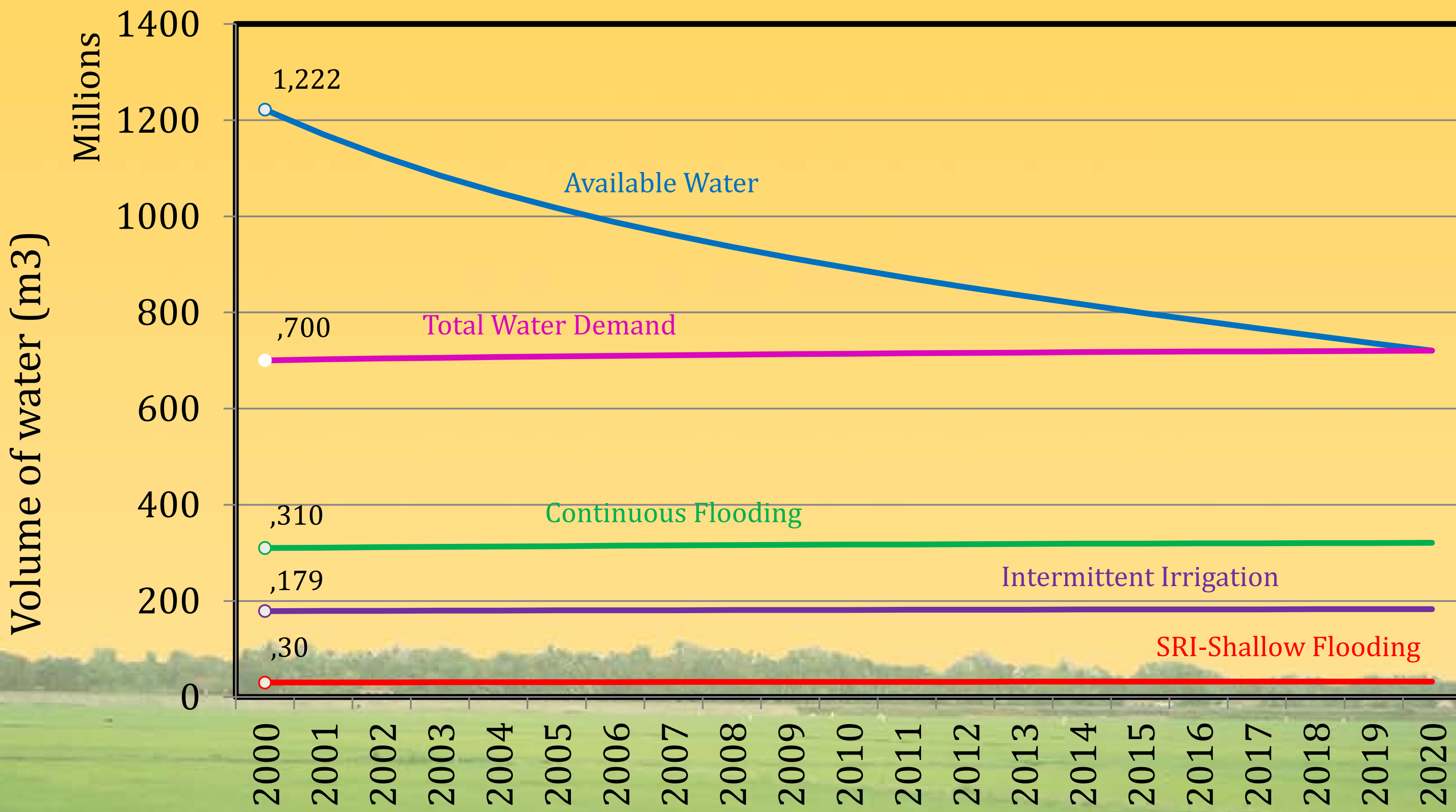


WATER BUDGET
3 Different Irrigation Schemes



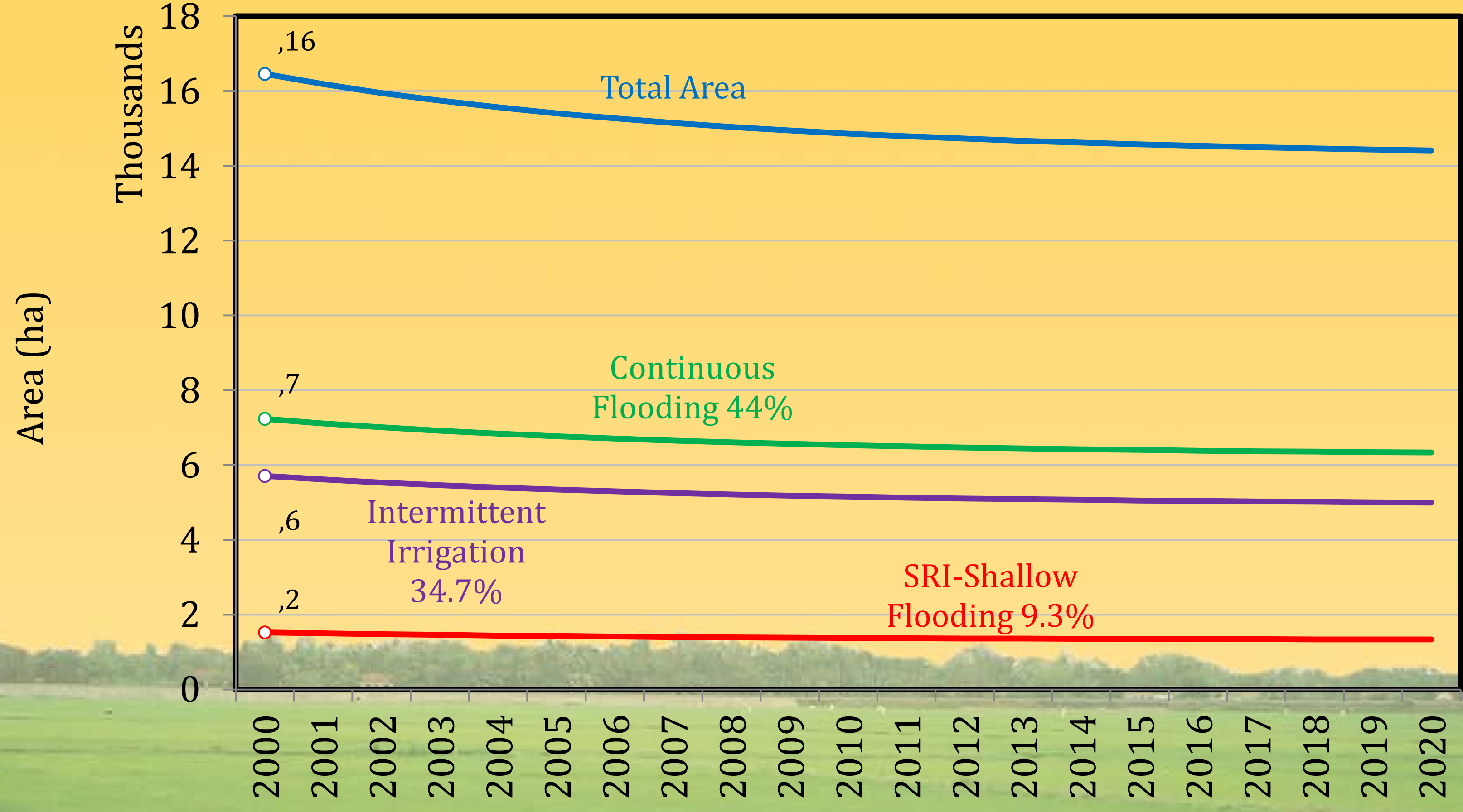
WATER BUDGET

Optimal Combination of 3 Different Irrigation Schemes



PADDY FIELDS AREA

Optimal Combination of 3 Different Irrigation Schemes



CONCLUDING REMARKS

- This paper introduced a concept of optimal water sharing based on a priority to obtain self-sufficiency of rice production in a watershed.
- Cicatih-Cimandiri watershed has experienced changes of land uses and covers, and water availability tends to decrease due to less annual rainfall and higher evapotranspiration.
- The water resources has not been available to produce the expected rice production under the present continuous flooding.
- One possible solution is to introduce more efficient water paddy field by gradually applying intermittent and SRI with shallow flooding irrigations.

THANK YOU FOR YOUR ATTENTION

CONCEPTUAL APPROACH
Available Water Resources

Available Water Resources

$$\frac{\Delta S}{\Delta t} = \alpha_R R - \alpha_{ET} ET_a - Q$$

S is water storage in the soil profile
R is rainfall,
ET_a is the actual evapotranspiration,
Q is surface runoff or river discharge
α is correction factor,
t is time.

$$\frac{\Delta S}{\Delta t} = 0 \rightarrow \; Q = \alpha_R R - \alpha_{ET} ET_a$$

$$Q_{AW} = \begin{cases} Q - Q_{mn} & Q > Q_{mn} \\ 0 & Q \leq Q_{mn} \end{cases}$$

Q_{AW} is the apparently available water resource
Q_{mn} is a recorded minimum river discharge

Available Water Supply

$$Q_T^S \geq Q_{AW} - Q_P^D$$

S and D indicate supply and demand
T and P indicate Total and Population

$$Q_T^S \geq Q_T^D = Q_{AG}^D + Q_{GI}^D + Q_{WI}^D$$

AG indicates Agriculture,
GI indicates General Industry
WI indicates Water Industry

CONCEPTUAL APPROACH
Water Demands

Water Demand for Domestics

Daily water need for domestics :

BAPPENAS (2006) : 80-185 liter/capita

Redjekiningrum (2011) :

$$Q_P^D = 144P$$

Verhults model:

$$P = P_\infty \left[1 + \left(\frac{P_\infty}{P_o} - 1\right)\right.$$

P is population,

∞ and o indicate in

γ is a fitted parame

t is time.

Water Demand for Agricultures

Yield function (Allen, *et.al.*, 1990):

$$\left(1 - \frac{Y_a}{\ }\right) = \rho\left(1 - \frac{ET_a}{\ }\right)$$

l and Evapotranspiration

nsitivity coefficient:

al and maximum values.

a

ercentage

d number of

seasons in a year.

Water Demand for General Industries

(water as supporting material)

consists of small, medium and big industries

$$Q_{GI}^D = \sum_j^{nj} Q_{GI,j}^D$$

j and nj are index and number of industry (nj=3).

Water Demand for Water Industries

(water as raw material)

$$Q_{WI}^D = \sum_k^{nk} Q_{WI,k}^D$$

k and nk are index and number of water industry.

CONCEPTUAL APPROACH
Optimal Water Sharing

Optimal Water Sharing

Objective Function:

$$0 \leq \epsilon = \left|Q_T^S - Q_T^D\right| \leq TOL$$

ε is absolute error

TOL is error tolerance.

A is the area of paddy fields.

α is proportional coefficient

CF is for Continuous Flooding

IT is for Intermittent Irrigation

SF is for Shallow Flooding

Constraint Functions:

$$Q_{AG}^D \geq Q_{AG,mn}^D$$

$$Q_{AG}^D = Q_{CF}^D + Q_{IT}^D + Q_{SF}^D$$

$$A_{AG}^D = A_{CF}^D + A_{IT}^D + A_{SF}^D$$

$$A_{CF}^D = \alpha_{CF} A_{AG}^D;\ A_{IT}^D = \alpha_{IT} A_{AG}^D;\ A_{SF}^D = \alpha_{SF} A_{AG}^D$$

$$\alpha_{CF} + \alpha_{IT} + \alpha_{SF} = 1$$

$$Q_{GI,mn}^D \leq Q_{GI}^D < \left(Q_T^S - Q_{AG}^D\right)$$

$$Q_{WI,mn}^D \leq Q_{WI}^D < \left(Q_T^S - Q_{AG}^D - Q_{GI}^D\right)$$