A DESIGN OF AN EXPERT SYSTEM FOR INTERCROPPING PLANNING

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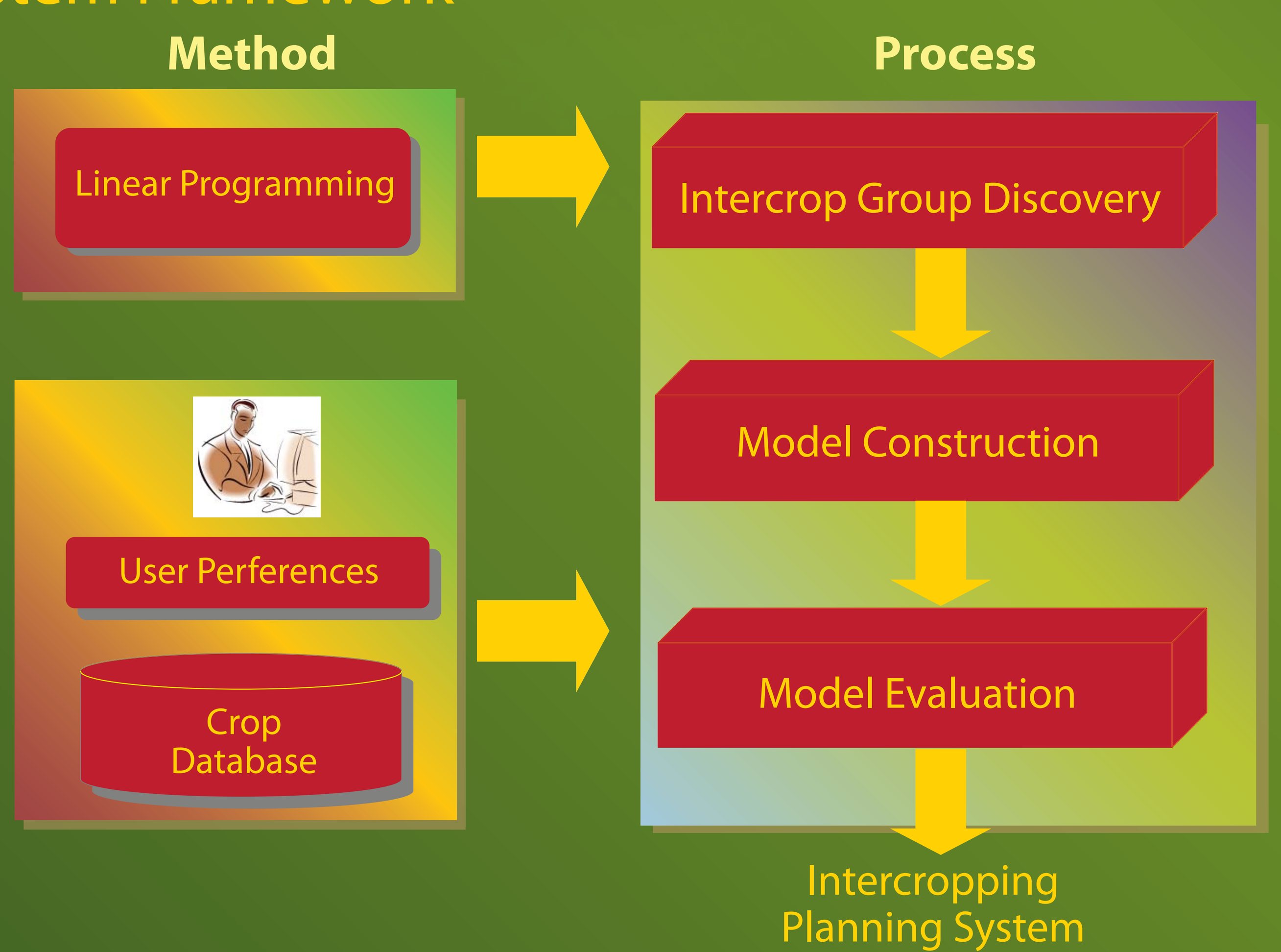
IN the past decades, the world's food production was mostly practiced by a monoculture system, i.e., growing only a crop over an area. The monoculture causes damages (or changes) to the biological diversity, especially the soil fertility. The sustainable agriculture is an approach of managing crop ecology in order to maintain the biological diversity, productions and long-term human existence. One methodology of sustainable agriculture is called Intercropping, i.e., multiple crops are planted in the same area. In the intercropping planning, many cultivating factors, such as diseases, sale prices and cultivating areas, must be concerned because those factors are affected to ecological succession and total income of production. Producers have to face with the complication of many factors in order to obtain the optimal plan under the concept of sustainable agriculture. This paper proposes an expert system model for intercropping planning. The model analysis and design were exhaustively discussed in terms of ecology as an agricultural expert, benefit as an economist and system analysis and design as an information technologist. This model has been proved to provide the efficient and practical intercropping plans.

System Framework



Vegetable database

An example of diseases in Kale and Long Bean

Diseases	Kale	LongBean
Fungi	1. Peronospora parasitica (downy mildew on leaves and heads) 2. Pythium ultimum (damping-off)	1. Cercospora capsici (leaf spot) 2. Colletotrichum lindemuthianum (anthracnose) 3. Erysiphe polygoni (powdery mildew) 4. Uromyes vignae (rust)
Bacteria	-	1. Pseudomonas phaseoli (bacterial blight)
Viruses	1. Cauliflower mosaic virus (CauMV) 2. Turnip mosaic virus (TuMV)	1. Cowpea aphidborne mosaic virus 2. Cowpea witches' broom virus

An example of data for planning calculations.

Database	Kale	Long Bean	Tomato
Sale price per plant (Baht), si	2.63	0.37	1.86
Periods of growing until harvesting (Day), di	85.5	50	133
Cultivating area per plant (Square meters), ai	0.09	0.02	0.3

Identification numbers (ID) and names of all vegetable used in the discovery process

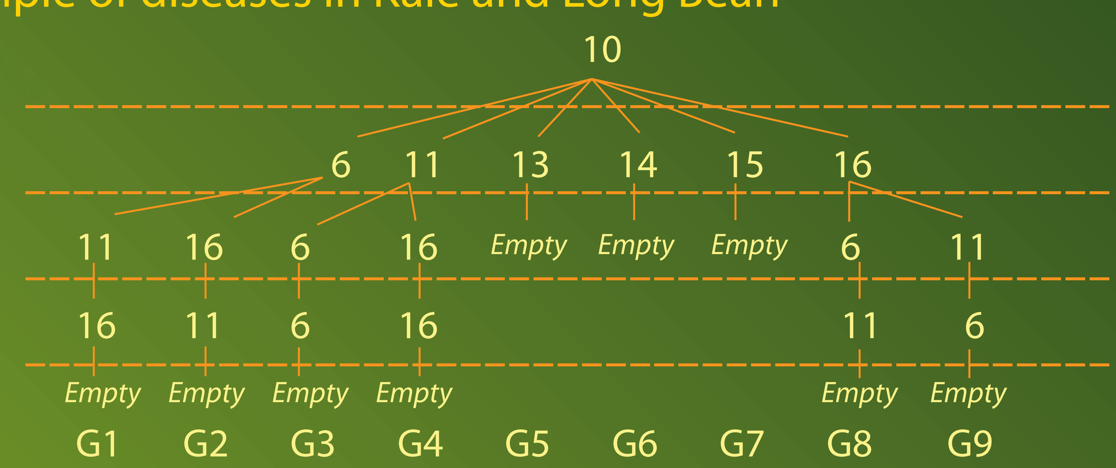
ID	Name	ID	Name
1	Cauliflower	10	Kale
2	Cabbage	11	Coriander
3	Celery	12	Water Spinach
4	Welsh Onion	13	Bird chili
5	Cucumber	14	Hot chili
6	Long Bean	15	Eggplant
7	Flowering White Cabbage	16	Tomato
8	Chinese Cabbage	17	Bitter ground
9	Head lettuce	18	Chinese Radish

Intercrop Group Discovery

All diseases of several vegetables related with Kale.

Diseases	Vegetable IDs								
	1	2	3	4	5	6	7	8	9
Fungal						✓			
Bacterial	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virus		✓	✓	✓	✓	✓			
All Diseaese						x			
	10	11	12	13	14	15	16	17	18
Fungal		✓		✓	✓	✓	✓		
Bacterial		✓	✓	✓	✓	✓	✓	✓	✓
Virus		✓	✓	✓	✓	✓	✓	✓	✓
All Diseaese		x		x	x	x	x		

An example of diseases in Kale and Long Bean



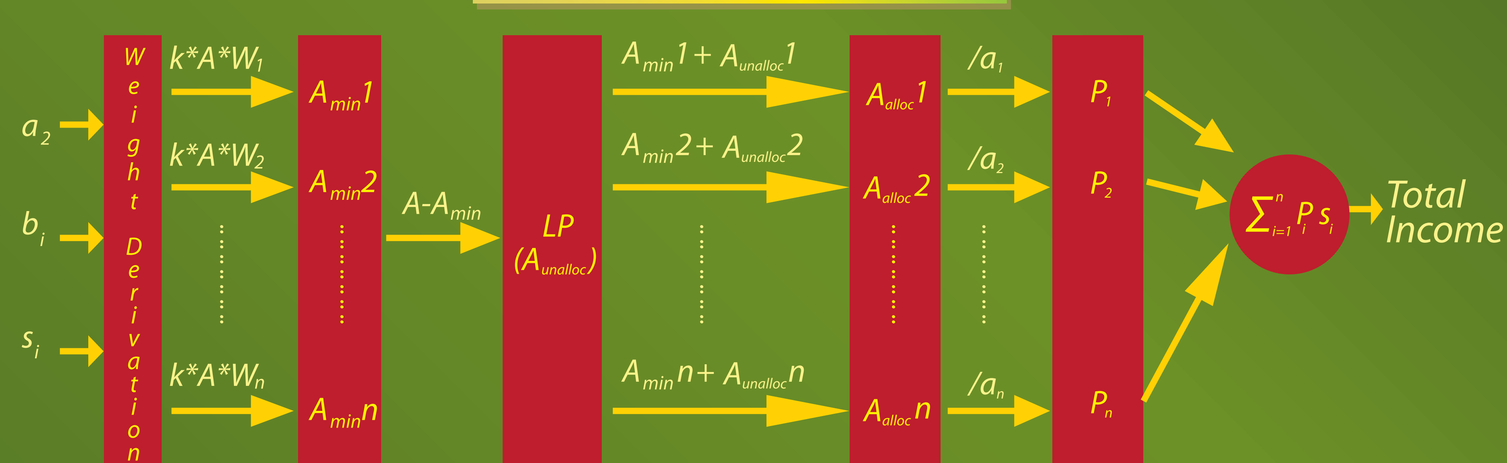
The unique intercrop groups that can be cultivated with Kale.

Groups	Vegetable IDs	Vegetable Names
1,2,3,4,8,9	6,10,11,16	Kale, Long bean Coriander and Tomato
5	10,13	Kale and Bird chili
6	10,14	Kale and Hot chili
7	10,15	Kale and Eggplant

Model construction process

Weight derivation from all the factors

$$W_i = \frac{a_i(s_i/d_i a_i)}{\sum_{k=1}^{n} a_k(s_k/d_k a_k))} = \frac{s_i/d_i}{\sum_{k=1}^{n}(s_k/d_k)}$$



Results of weight derivation from all the factors.

Parameters	Kale	Long Bean	Tomato
All the factors of each vegetable,	0.34	0.37	0.05
Proportion of a spcific area of each vegetable (weight),	0.59	0.14	0.27

Model Evaluation

Results of allocated areas of each vegetable and total income.

	Constant Values (k)				
	0	0.25	0.05	0.75	1.00
Kale	0	235.96	471.92	707.88	943.83
Long Bean	0	56.77	113.53	170.88	227.06
Tomato	0	107.23	214.55	321.83	429.11
	1,600.00	1,200.00	800.00	400.00	0
Kale	1,599.93	1,435.68	1,271.52	1,107.72	943.83
Long Bean	0.06	56.92	113.68	170.38	227.06
Tomato	0	107.40	214.8	321.83	429.11
Total Income (Bath)	*46,754.62*	*43,672.66*	*40,591.48*	*37,517.85*	*34,440.85*

THIS paper proposes an expert system model for intercropping planning in order to maximize income while minimize the economic risk. The model analysis and design were exhaustively discussed in terms of ecology as an agricultural expert, benefit as an economist and system analysis and design as an information technologist. Several cultivating factors have been investigated and applied to construct the proposed model. The model was evaluated by comparing with a linear programming method. The experimental results revealed that the linear programming method provided the highest income; but it could not accomplish in the risk minimization. On the other hand, the proposed model could minimize the risk and also obtained at least 74% when compared with the linear programming method.