Application of Korean Specific Data to Economic Cost Estimation by KOSCA-MACCS2

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1. Introduction

MACCS2 (MELCOR Accident Consequence Code System Version 2) is a code to estimate consequences of airborne radioactive releases, which are doses, health effects, and economic impacts [1][2]. It gives a full accounting for economic costs due to mitigating actions including emergency response actions and intermediate- and long-term protective actions. However, default values for various data provided by MACCS2 such as population, weather, food, and economic cost are far from current domestic condition. In the case of economic cost data, related default values came from MACCS and WASH-1400.

KAERI (Korea Atomic Energy Research Institute) has been developed a Korean-specific level 3 PSA (Probabilistic Safety Assessment) code package based on MACCS2 to reflect domestic condition for off-site consequence analysis. To this end, we performed a study on the domestic specific technical issues for level 3 PSA, which are a dose conversion factor, food chain model, atmospheric dispersion model, and domestic-specific economic effect model. Based on the study, we developed a level 3 PSA code, so-called KOSCA-MACCS2 (Korean-specific Off-Site Consequence Analysis based on MACCS2) [3].

The purpose of this paper is to introduce economic cost variable provided by KOSCA-MACCS2 and application of Korean-specific data to the related economic cost estimation with KOSCA-MACCS2.

2. Methods and Results

2.1 Economic Cost Variables by KOSCA-MACCS2

Basically economic cost variables by KOSCA-MACCS2 conform to those of MACCS2. Economic cost categories and related input variables considered by KOSCA-MACCS2 are as follows:

- Food and lodging costs for short-term relocation of people who are evacuated or relocated
  - EVACST: daily cost of compensation for evacuees and short-term relocates during the emergency-phase period
  - RELCST: daily cost of compensation for individuals removed from their homes due to intermediate-phase relocation

- Decontamination costs for property
  - LVLDEC: the number of decontamination levels
  - CDFRM: the farmland decontamination cost
  - CDNFRM: the nonfarmland decontamination cost

- Economic losses incurred while property (farm and nonfarm) is temporarily interdicted
  - POPCST: the per capita removal cost for temporary or permanent relocation of population and businesses in a region rendered uninhabitable during the long-term phase time period
  - DPRATE: the depreciation rate that applies to property improvements during a period of interdiction
  - DSRATE: the expected rate of return from land, buildings, equipment, and etc.

- Economic losses resulting from milk and crop disposal
  - FRCFRM: the average fraction of land in the region devoted to farm production
  - FRMPRD: the value of the average annual farm production (gross sales) in the region
  - DPFRCT: the fraction of annual farm production (gross sales) in the region resulting from dairy production

- Economic losses due to permanent interdiction (Condemnation) of property
  - VALWF: the value of farm wealth in the region
  - FRFIM: the fraction of farm wealth in the region due to improvements
  - VALWNF: the value of the nonfarm wealth in the region
  - FRNFIM: the fraction of nonfarm wealth in the region due to improvements

Table 1 shows the economic cost results by KOSCA-MACCS2

Table 1 Economic Cost Results by KOSCA-MACCS2

Output Variable	Description
TOTAL ECONOMIC COSTS (long term)	sum of population- and farm-dependent costs

POP.-DEPENDENT COSTS (long term)	sum of population-dependent decontamination, interdiction, and condemnation costs.
FARM-DEPENDENT COSTS (long term)	sum of farm-dependent decontamination, interdiction, and condemnation costs as well as milk and crop disposal costs.
POP.-DEPENDENT DECONTAMINATION COST	nonfarm property (i.e., property associated with resident population) decontamination cost
FARM-DEPENDENT DECONTAMINATION COST	farm property decontamination costs
POP.-DEPENDENT INTERDICTION COST	depreciation and deterioration cost of nonfarm property during the period
FARM-DEPENDENT INTERDICTION COST	depreciation and deterioration cost of farm property during the period
POP.-DEPENDENT CONDEMNATION COST	compensation paid for permanent loss of nonfarm property plus the cost of population removal.
FARM-DEPENDENT CONDEMNATION COST	compensation paid for permanent loss of farm property
MILK DISPOSAL COSTS	compensation for lost milk sales during a quarter of a year
CROP DISPOSAL COSTS	compensation for lost nonmilk crop sales during a full year.
EMERGENCY PHASE COSTS	per-diem costs to compensate people for being away from home due to evacuation and relocation during the phase
INTERMEDIATE PHASE COSTS	per-diem costs to compensate people for being away from home due to relocation for the duration of the phase

2.2 Application of Korean-specific Data to Economic Cost Estimation

Data sources to substitute the US data of input variable for cost estimation with Korean-specific data in the KOSCA-MACCS2 are as follows [4-6]:

- Data by Statistics Korea
- Land Cover Map by Korea Ministry of Environment
- Data by Bank of Korea
- Extern- E
- UNESCO Chernobyl Forum
- Report by FOE (Friends of the Earth)-KOREA
- Data by MACCS2
- Others

For the decontamination related input variables, there are no data sources to reflect domestic-specific features since data for the variables should come from experience data. Therefore we apply data by Extern-E, UNESCO Chernobyl Forum, and MACCS2 to decontamination cost related input variables. Table 2 shows the plan for application of Korean-specific data to economic cost estimation.

Table 2 Plan for Application of Korean-specific Data to Economic Cost Estimation

Input Variable	Estimated value
EVACST ($/person-day)	- Transport cost: assumption by expert judgment and Report by FOE-KOREA - Accommodation cost: estimation with Extern-E - Loss of income: estimation with household income by Statistics Korea
RELCST ($/person-day)	same to above
LVLDEC	depends on data available
CDFRM ($/hectare)	estimation with Extern-E data, UNESCO Chernobyl Forum data, and MACCS2 data
CDNFRM ($/person)	same to above
POPCST ($/person)	- Human capital and physical capital losses: estimation with GRDP (Gross Regional Domestic Product) and population data by Statistics Korea - Moving expense: estimation with Report by FOE-Korea
DPRATE (/year)	data by Bank of Korea
DSRATE (/year)	MACCS 2 default data
FRCFRM	estimation with Land Cover Map
FRMPRD ($/hectare)	- Agricultural income: estimation with agricultural GRDP and the number of agricultural households by Statistics Korea - Dairy income: estimation with dai

	ry production by Statistics Korea
DPFRCT	same as above
VALWF ($/hectare)	estimation with farm household economy data and by Statistics Korea
FRFIM	Estimation with farm household economy data and land category data by Statistics Korea
VALWNF ($/person)	household asset data and the number of households by Statistics Korea
FRNFIM	Data from press release

2.3 Results of Application of Korean-specific Data to Economic Cost Estimation

This section is to describe the application results based on the method by Table 2. There are two kinds of formats to input data for economic cost variables. One is for user input for a value such as the depreciation rate (DPRATE) or an average value such as the value of the average annual farm production in the region (FRMPRD) and the other one is for creating Site Data File. The Site Data File is used to input data for the each surrounding region instead of average value. Contained in the Site Data File are the geometry data used for the site (spatial intervals), population distribution, fraction of the area that is land, watershed data for the liquid pathways model, information on agricultural land use and growing seasons, and regional economic information. Table 3 shows the user input format data reflecting Korean-specific features for economic cost estimation. We apply an exchange rate of ₩1,050 to the dollar in this paper.

Table 3 User Input Data Reflecting Korean-specific Features for Economic Cost Estimation

Input Variable	Estimated value	Default value by MACCS2
EVACST ($/person-day)	86.61	27.00
RELCST ($/person-day)	86.61	27.00
LVLDEC	1	2
CDFRM ($/hectare)	3,555.91	562.5 1250.
CDNFRM ($/person)	20,295.29	3000. 8000.
POPCST ($/person)	20,856.92	5000.
DPRATE (/year)	0.035	.20
DSRATE (/year)	0.12	.12
FRFIM	0.256	0.25
FRNFIM	0.45	0.8

In Table 3, for the number of decontamination levels (LVEDEC), each decontamination level represents an alternative strategy that would reduce the projected long-term groundshine and resuspension doses. Up to three levels of decontamination can be defined. We selected a decontamination level as one stage while MACCS2 default value used a two stage since data we applied in this research can provide data for only one stage.

Table 4 is summary of Site Data File Data reflecting Korean-specific features for economic cost estimation. We estimated data by administrative divisions for five economic cost variables.

Table 4 Site Data File Data Reflecting Korean-specific Features for Economic Cost Estimation

Province	FRCFRM	FRMPRD ($/h)	DPFRCT	VALWF ($/h)	VALWNF ($/p)
1	0.05	161,707.4	0.001	25,610.5	124,503.1
2	0.16	38,465.4	0.008	9,592.3	64,839.2
3	0.16	10,386.5	0.071	21,751.4	69,483.7
4	0.27	7,143.9	0.069	30,338.5	68,197.9
5	0.27	15,664.0	0.013	11,567.7	54,369.3
6	0.14	4,269.4	0.001	20,242.5	70,519.8
7	0.15	7,466.6	0.037	14,222.9	81,626.0
8	0.25	13,912.8	0.228	329,841.6	94,860.4
9	0.10	17,734.2	0.025	105,567.7	56,710.8
10	0.20	11,617.0	0.060	125,645.5	76,534.3
11	0.32	13,662.7	0.086	160,547.8	62,534.3
12	0.29	11,296.3	0.052	84,963.0	57,092.3
13	0.28	8,558.9	0.044	77,496.1	44,529.9
14	0.18	14,103.6	0.036	129,033.8	66,247.4
15	0.20	16,601.0	0.036	152,941.8	66,400.4
16	0.39	15,320.2	0.016	178,333.1	68,116.4

With the application Korea-specific data to economic cost estimation and related results, we developed Economic Cost Manager as a part of KOSCA-MACCS2. Figure 1 shows an input module of Economic Cost Manager of KOSCA-MACCS2.
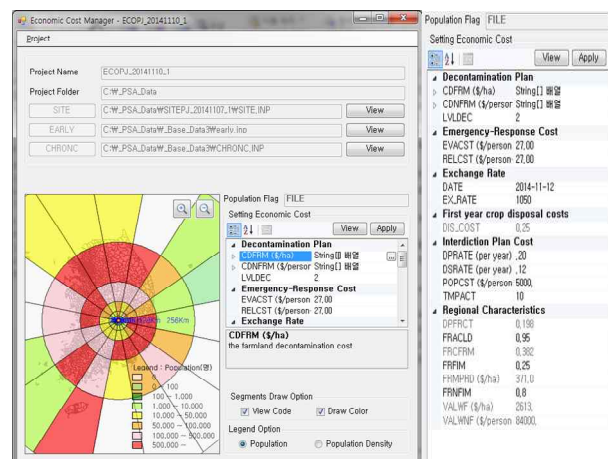

Figure 1 Input Module of Economic Cost Manager of KOSCA-MACCS2

3. Conclusions

In this paper, we introduced economic cost variable provided by KOSCA-MACCS2 and suggested the application plan of Korean-specific data to the related economic cost estimation. To this end, we considered data sources for those economic cost variables to reflect Korea-specific features such as data by Statistics Korea or Bank of Korea etc. For the decontamination related variables, we applied foreign literatures to apply data, which are Extern-E and UNESCO Chernobyl Forum data. Based on the data resources we estimated data for input variables related to economic cost estimation.

There are some limitations on economic cost related variables in KOSCA-MACCS2 since KOSCA-MASSC2 follows the frame of MACCS2 which is unsuitable for reflecting domestic specific features. For example, MACCS2 considers milk production income and milk disposal cost however milk is less important than other food. Therefore we have a plan to develop an off-site consequence analysis code reflecting Korea-specific environments in future.

Acknowledgement

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