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Supplement of

Assessment on the rates and potentials of soil organic carbon sequestration in agricultural lands in Japan using a process-based model and spatially explicit land-use change inventories – Part 2: Future potentials

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412 **Supplementary Material A. Method to create spatially-explicit future land-use map in year 2020.**

413

414 *Grid system*

415 The grid system created in this study has geographical dimensions and coordinate system identical to those in
416 Standard Grid Cell (SGC) system created by former Management and Coordination Agency, the Government of
417 Japan, which has been employed in national statistical surveys in Japan. SGC has four class of layers differs in
418 cell size and its fourth class has same spatial resolution as our grid system created for this study, with spatial
419 resolution of 1/1200 and 1/800 degree (3.0 and 4.5 second), along latitudinal and longitudinal lines, respectively.
420 Size of individual cell of the grid equivalents to a parcel of a square land ca. 100 m on a side, with an area of ca.
421 10,000 m² (1 hectare).

422

423 *Geographical data sources and interpretation of land-use/land-cover in historical period during year*
424 *1970-2006*

425 Brief description on each geographical data sources (with their abbreviated titles in bold) are listed below;

426 1) **LU**: Land Use Fragmented Mesh Version 1.1 in National Land Numerical Information, created by Ministry
427 of Land, Infrastructure, Transport and Tourism, the Government of Japan. Spatial resolution of 100 x 100 m,
428 along latitudinal and longitudinal lines, respectively. LU map products have been synthesized from various data
429 sources, such as topographical maps, current land usage status maps, satellite images (Landsat, Terra-Aster,
430 ALOS etc.), in combination with several data tables on land-use statistics. Created for fiscal year (FY) 1976,
431 1987, 1991, 1997, and 2006. From 11 to 16 land-use classifications (paddy field, upland field, orchard, forest,
432 waste area, building use, trunk transportation land, lake, river, etc.) were employed, with the number of
433 classifications differing among some groups of survey periods.

434 2) **VG**: Vegetation map from Vegetation Naturalness Survey conducted in National Survey on the Natural
435 Environment, created by Ministry of Environment (MOE), the Government of Japan, under authority of Article 4
436 of the Nature Conservation Law. The VG is a collection set of vector maps with approximately 270 legends of
437 plant communities. Map products created in FY 1983-1986, FY 1989-1993, and FY 1994-1998, compiled in the
438 3rd, 4th, and 5th survey, respectively, were selected and used in this study. A new nation-wide legend, produced
439 in the 6th survey to unify and arrange locally legends used in predecessor maps, was employed in this study and
440 applied to all predecessor maps by using a legend conversion table provided by MOE.

441 3) **AL**: Agricultural land map from Basic Survey on Improvement of Agricultural Production Base, created by
442 Ministry of Agriculture, Forestry, and Fisheries (MAFF), the Government of Japan. Vector maps of agricultural
443 fields classified into 4 land-use types (paddy field, upland field, orchard, and grassland). Created in 1992 and
444 2001. In synthesis of this map product, in some cases, polygons of these types of agricultural fields had been
445 modified so that sum of the area of polygons in each land-use category to be consistent with the agricultural
446 statistics at prefectural level, and thus, may include some bias.

447 A decision tree was created to decide land-use of each grid cell using legends in LU, VG, and AL as input

448 parameters, to enable compilation of different datasets having different type of information on land-use, legends,
 449 and time period. The decision tree was built using structured query language (SQL) and implemented as a
 450 PostgreSQL function. The LU, VG, and AL, in overlapping, nearby, or different periods were selected and
 451 compiled together to make 6 different groups tagged with different time period, and were applied as input data for
 452 the decision tree as summarized in Table A1. As result, grid cells were classified into 9 land-use types; 01 paddy
 453 field (PD), 02 upland field (UP), 03 orchards (OC), 04 managed grassland (MG), 05 unmanaged grassland (UG),
 454 06 forest lands (FL), 07 wetlands (WL), 08 settlements (ST), and 09 other lands (OL).

455 As any of these three geographical data sources alone could not fulfil requirement for our nation-wide
 456 simulation due to insufficient classification, accuracy, or time interval, we employed strategy to compile these
 457 different geographical data sources to set off merits against the deficit, and to interpret it; e.g. LU had more time
 458 series data than other data sources, however, in FY 1991-2006, its classification on agricultural land had only two
 459 legend items, 'paddy field' and 'other agricultural fields'. VG had more detail classifications but had only three
 460 time series data. Thus LU in FY 1991-2006 was superimposed with VG to enable subdivision of the legend item
 461 'other agricultural fields' in LU into 'paddy field', 'upland field', 'orchards', and 'grasslands'.

462 Formulation of the decision tree was rather arbitrary and, thus, preliminary. A preliminary validation on the
 463 land-use maps using geographical reference dataset on agricultural land management collected in the Basic Soil
 464 Environment Monitoring Project, Stationary Monitoring conducted in year 1979-1998 showed that accuracy rate
 465 of the land-use map for paddy field, upland field, orchards, and managed grassland were 89, 76, 75, and 71 %,
 466 respectively, on average through four waves of the monitoring survey.

467
 468

Table A1 Dataset used to composite land-use map.

Dataset	Period	land-use map				
		1976	1987	1991	1997	2006
Land use fragmented mesh data, Version 1.1 (LU) ¹⁾	FY 1976	•				
	FY 1987		•			
	FY 1991			•		
	FY 1997				•	
	FY 2006					•
Vegetation map (VG) ²⁾	FY 1983-1986	•	•			
	FY 1989-1993			•		
	FY 1994-1998				•	•
Agricultural land map (AL) ³⁾	FY 2001					•

469 1) National Land Numerical Information (Land Use Fragmented Mesh), Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan.
 470 <http://nlftp.mlit.go.jp/ksj-e/jpgis/datalist/KsjTmplt-L03-b.html>

471 2) Vegetation map, Vegetation Naturalness Survey, National Survey on the Natural Environment, Ministry of Environment, Japan.

472 3) Agricultural land map, Basic Survey on Improvement of Agricultural Production Base, Ministry of Agriculture, Forestry, and Fisheries, Japan.

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Table A2 Spatial-temporal inventory data employed in simulation.

Data type	Spatial resolution	Begin	End	Description
agricultural activity	prefectural	1970	2008	estimate based on national statistics and survey on agriculture
		2009	2020	business as usual scenario or linear change toward future target in 2020 ^[1]
		2021	2100	identical to conditions in 2020 (no temporal change)
climate	latitude: 1/120 ° longitude: 1/80 ° (ca. 1 x 1 km)	1970	1978	10 years mean values from observation between 1979 and 1988
		1979	2009	Observation
		2010	2100	future projection of GCM and CO ₂ emission scenarios
land-use	latitude: 1/1200 ° longitude: 1/800 ° (ca. 0.1 x 0.1 km)	1970	1976	identical to land-use map 1976 (no temporal change)
		1976	1987	interpolation of land-use map 1976 and 1987
		1987	1991	interpolation of land-use map 1987 and 1991
		1991	1997	interpolation of land-use map 1991 and 1997
		1997	2006	interpolation of land-use map 1997 and 2006
		2006	2020	interpolation of land-use map 2006 and that projected for 2020
		2021	2100	identical to land-use map projected for 2020 (no temporal change)

476

477 *Future land-use/land-cover data creation*

478 Further, we created future land-use map to be consistent with figures on agricultural land area presented in
479 future agricultural activity scenario created by Agricultural Production Bureau (APB), MAFF. Future scenarios
480 on agricultural activity in accordance with figures presented in the Basic Plan for Food, Agriculture and Rural
481 Areas planned by MAFF with targets set for year 2020 (MAFF-BP) had been created by APB together with
482 business-as-usual scenario (BAU) as baseline scenario (hereafter referred as 'APB scenarios' collectively).

483 A set of PL/pgSQL functions, a simple land-use change map creation tool (LUC-pg, tentatively named), was
484 developed to enable creation of spatially explicit future land-use map using A) current (latest) land-use map, and
485 B) a land-use change matrix (LUC-matrix), which contains figures on areas of planned or predicted land-use
486 changes to occur, specifying land-use types before and after the occurrence of land-use change, as employed in
487 Approach 2 in GPG-LULUCF for identification of land-use change. The LUC-pg can use LUC-matrix of any
488 arbitrary geographical entity, such as city, prefecture, or country. The LUC-pg does 1) grouping grid cells based
489 on any arbitrary feature or combination of features (e.g. land-use and agricultural commune), 2) tag those
490 grouped grid cells with the order of priority in land-use conversion to occur determined by any arbitrary
491 properties or geographical functions (e.g. land prices, distance to rail station, function of these two parameters,
492 etc.), and 3) proceed conversion of land-use of the grouped grid cells on sorted table according to the order of
493 priority, which continues until it will reach the target levels of total area of land-use change prescribed in the
494 future plan or scenario.

495 Future land-use map for year 2020 were created by applying LUC-pg to land-use map in year 2006 with APB
496 scenarios. As parameter settings for LUC-pg application, the grid cells were grouped by combination of land-use
497 type and agricultural commune, and the order of priority in land-use conversion was determined by order of total
498 area of the grouped grid cells within each prefecture.

499 As only target figures on total areas of paddy fields, upland crop fields, orchards, and managed grasslands at
500 prefectural level in future had been given in APB scenarios, firstly, we created LUC-matrix in accordance with
501 the APB scenarios with some arbitrary assumptions in land-use change patterns (i.e. converted from/to). One
502 major assumption was made with regard to conversion of agricultural lands (paddy fields, upland crop fields,
503 orchards, and managed grasslands) to non-agricultural lands, with assuming two different contrasting and rather
504 exaggerated cases on the 'converted to' land-use types;

505 Urbanization (URB): Lands converted from agricultural lands will be converted to settlements (no organic
506 matter input to soil, no vegetation cover).

507 Abandonment (ABN): Land converted from agricultural lands will be converted to unmanaged grasslands
508 (organic matter supplied at a fixed rate, covered by vegetation).

509 As a result, two different future maps were created for each of the two APB scenarios in correspondent with
510 these different two assumptions.

511 For a group of a set of six of the land-use maps from 1976 to 2006 and a map of future scenario 2020, for each
512 grid cells or a group of grid cells, a year of land-use conversion were generated between years of two consecutive
513 land-use maps using random number generation function of PostgreSQL. This operation could provide an
514 interpolation of changes in total area of each land-use types at prefectural level during intermittent years between
515 two consecutive but discontinuous maps.

516 It should be noted that, prior to the generation of land-use conversion years, each of the six land-use maps was
517 modified by applying LUC-pg with arbitrary formulated LUC-matrix so that total area of paddy field, upland
518 field, orchards, and managed grassland to be in a good agreement with corresponding figures in national
519 agricultural statistics in corresponding year.

520 Necessity or significance on the application of LUC-pg for existing land-use map for past and current, in view
521 of production for more appropriate land-use change data for LULUCF accounting, were questionable as it would
522 cause decline of map quality. Such operation should be performed only when figures in LUC-matrix were
523 confirmed to have greater accuracy and credibility than geographical map.

524 Transformation of geodetic reference system, rasterization of the vector map, were performed using GDAL,
525 OGR, GRASS GIS, Quantum GIS (QGIS), and tools provided by The Open Source Geo-spatial Foundation
526 (OSGeo). Computational operations to compile LU, VG, and AL dataset and to superimpose them on the grid
527 system were performed using PostGIS on PostgreSQL database.

528 *Land-use change matrix (LUC matrix) used for future land-use scenarios from year 2006 to 2020.*

529

530 Table A3 Land-use change matrix for different future land-use scenarios from year 2006 to 2020 (unit: 10³ ha); 01 PD: paddy fields,

531 02 UP: upland crop fields, 03 OC: orchards, 04 MG: managed grasslands, 05 UG: unmanaged grasslands, 06 FL: forest lands, 07

532 WL: wetlands, 08 ST: settlements, 09 OL: other lands.

533

a) BAU & Urbanization scenario

		To									From		
		01 PD	02 CL	03 OC	04 MG	05 UG	06 FL	07 WL	08 ST	09 OL	TOT ¹⁾	REM ²⁾	CON ³⁾
From	01 PD	1,635	0	0	0	0	0	0	166	0	1,800	1,635	166
	02 CL	0	1,741	0	0	0	0	0	129	0	1,871	1,741	129
	03 OC	0	0	270	0	0	0	0	58	0	328	270	58
	04 MG	0	0	0	578	0	0	0	51	0	628	578	51
	05 UG	0	0	0	0	2,316	0	0	0	0	2,316	2,316	0
	06 FL	0	0	0	0	0	24,725	0	0	0	24,725	24,725	0
	07 WL	0	0	0	0	0	0	917	0	0	917	917	0
	08 ST	0	0	0	0	0	0	0	2,645	0	2,645	2,645	0
	09 OL	0	0	0	0	0	0	0	0	1,971	1,971	1,971	0
To	TOT ¹⁾	1,635	1,741	270	578	2,316	24,725	917	3,049	1,971	37,201		
	REM ²⁾	1,635	1,741	270	578	2,316	24,725	917	2,645	1,971	36,797		
	CON ³⁾	0	0	0	0	0	0	0	404	0	404		

1) total, 2) sum of the area for land remaining in the same land-use category, 3) sum of the area for land converted to other land-use types

b) BAU & Abandonment scenario

		To									From		
		01 PD	02 CL	03 OC	04 MG	05 UG	06 FL	07 WL	08 ST	09 OL	TOT	REM	CON
From	01 PD	1,635	0	0	0	166	0	0	0	0	1,800	1,635	166
	02 CL	0	1,741	0	0	129	0	0	0	0	1,871	1,741	129
	03 OC	0	0	270	0	58	0	0	0	0	328	270	58
	04 MG	0	0	0	578	51	0	0	0	0	628	578	51
	05 UG	0	0	0	0	2,316	0	0	0	0	2,316	2,316	0
	06 FL	0	0	0	0	0	24,725	0	0	0	24,725	24,725	0
	07 WL	0	0	0	0	0	0	917	0	0	917	917	0
	08 ST	0	0	0	0	0	0	0	2,645	0	2,645	2,645	0
	09 OL	0	0	0	0	0	0	0	0	1,971	1,971	1,971	0
To	TOT	1,635	1,741	270	578	2,720	24,725	917	2,645	1,971	37,201		
	REM	1,635	1,741	270	578	2,316	24,725	917	2,645	1,971	36,797		
	CON	0	0	0	0	404	0	0	0	0	404		

1) total, 2) sum of the area for land remaining in the same land-use category, 3) sum of the area for land converted to other land-use types

534

c) MAFF-BP & Urbanization scenario

		To									From		
		01 PD	02 CL	03 OC	04 MG	05 UG	06 FL	07 WL	08 ST	09 OL	TOT	REM	CON
From	01 PD	1,800	0	0	0	0	0	0	0	0	1,800	1,800	0
	02 CL	60	1,756	0	55	0	0	0	0	0	1,871	1,756	115
	03 OC	0	0	306	4	0	0	0	18	0	328	306	22
	04 MG	0	0	0	628	0	0	0	0	0	628	628	0
	05 UG	0	0	0	0	2,316	0	0	0	0	2,316	2,316	0
	06 FL	0	0	0	0	0	24,725	0	0	0	24,725	24,725	0
	07 WL	0	0	0	0	0	0	917	0	0	917	917	0
	08 ST	0	0	0	0	0	0	0	2,645	0	2,645	2,645	0
	09 OL	0	0	0	0	0	0	0	0	1,971	1,971	1,971	0
To	TOT	1,860	1,756	306	687	2,316	24,725	917	2,663	1,971	37,201		
	REM	1,800	1,756	306	628	2,316	24,725	917	2,645	1,971	37,064		
	CON	60	0	0	59	0	0	0	18	0	137		

1) total, 2) sum of the area for land remaining in the same land-use category, 3) sum of the area for land converted to other land-use types

d) MAFF-BP & Abandonment scenario

		To									From		
		01 PD	02 CL	03 OC	04 MG	05 UG	06 FL	07 WL	08 ST	09 OL	TOT	REM	CON
From	01 PD	1,800	0	0	0	0	0	0	0	0	1,800	1,800	0
	02 CL	60	1,756	0	55	0	0	0	0	0	1,871	1,756	115
	03 OC	0	0	306	4	18	0	0	0	0	328	306	22
	04 MG	0	0	0	628	0	0	0	0	0	628	628	0
	05 UG	0	0	0	0	2,316	0	0	0	0	2,316	2,316	0
	06 FL	0	0	0	0	0	24,725	0	0	0	24,725	24,725	0
	07 WL	0	0	0	0	0	0	917	0	0	917	917	0
	08 ST	0	0	0	0	0	0	0	2,645	0	2,645	2,645	0
	09 OL	0	0	0	0	0	0	0	0	1,971	1,971	1,971	0
To	TOT	1,860	1,756	306	687	2,334	24,725	917	2,645	1,971	37,201		
	REM	1,800	1,756	306	628	2,316	24,725	917	2,645	1,971	37,064		
	CON	60	0	0	59	18	0	0	0	0	137		

1) total, 2) sum of the area for land remaining in the same land-use category, 3) sum of the area for land converted to other land-use types

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536

537

538 A step-by-step guidance on the method to create spatially-explicit future land-use map with specified future
 539 land area target or prediction.

540
 541 **[Step 1]** Define Land-use Change Unit (LUC-Unit) by aggregating grid-cells with grouping by
 542 prefecture, city, agricultural commune, zoning (e.g. for land-use change regulation) and land-use
 543 type. Calculate area of the LUC-Unit. PD: paddy fields, UP: upland crop fields.

544




Cell ID	Prefecture	City	Agcom ID	Zone	Soil	Land-use	Cell area	Unit ID	Unit area
1	08	001	101	1	A	PD	1	1	3
2	08	001	101	1	A	PD	1	1	3
3	08	001	101	1	A	PD	1	1	3
4	08	001	101	1	B	UP	1	2	2
5	08	001	101	1	B	UP	1	2	2
6	08	001	102	1	B	UP	1	3	1
7	08	001	102	1	B	PD	1	4	2
8	08	001	102	1	B	PD	1	4	2
9	08	001	102	1	C	PD	1	5	1
10	08	001	103	1	C	PD	1	6	1
...

545

546 **[Step 2]** Assign Land-use Change Likelihood Index (LUC-LI), either as numeric or integer data type
 547 indicating relative likelihood for land-use conversion to occur, according to user-specified model
 548 of land-use change trend, land-use planning, and policy implementation. The LUC-LI can be set
 549 by many different ways with different objectives. By adding various geographical information as
 550 additional attributes of grid cells, e.g. distance from train station, land price, population in city
 551 or smaller size local community, and soil types, etc., may help to build more sophisticated and
 552 complex model to predict land-use change that takes account multiple geographical attributes
 553 data as input parameters. PD: paddy fields, UP: upland crop fields.

554



Cell ID	Prefecture	City	Agcom ID	Zone	Soil	Land-use	Cell area	Unit ID	Unit area	LUC-LI
1	08	001	101	1	A	PD	1	1	3	
2	08	001	101	1	A	PD	1	1	3	
3	08	001	101	1	A	PD	1	1	3	
4	08	001	101	1	B	UP	1	2	2	
5	08	001	101	1	B	UP	1	2	2	
6	08	001	102	1	B	UP	1	3	1	
7	08	001	102	1	B	PD	1	4	2	
8	08	001	102	1	B	PD	1	4	2	

9	08	001	102	1	C	PD	1	5	1	
10	08	001	103	1	C	PD	1	6	1	
...

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556

[Step 3] Define range of grid-cells for which land-use change to occur by the following steps;

557

Step 3.1 - Select a land-use type listed in land-use change matrix (e.g. Paddy fields (PD)) prepared for a geographical entity (e.g. a zone in a prefecture) and obtain a set of land-use change patterns with specified area of land-use conversions for each. Probability of land-use change (%) is calculated according to relative proportion of the specified area of land-use conversion among all other land-use change patterns, as indicated below in table. In this example, a total 4,000 ha (1,000 + 3,000) of Paddy fields should be converted to other land-use types, with probability to be converted to Upland crop fields and Settlements equal to 25 and 75 %, respectively.

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		Unit	To								
			01 PD	02 UP	03 OC	04 MG	05 UG	06 FL	07 WL	08 ST	09 OL
From	01 PD	ha	16,000	1,000	0	0	0	0	0	3,000	0
		%	-	25	0	0	0	0	0	75	0

565

01 PD: paddy fields, 02 UP: upland crop fields, 03 OC: orchards, 04 MG: managed grasslands, 05 UG: unmanaged grasslands, 06 FL: forest lands, 07 WL: wetlands, 08 ST: settlements, 09 OL: other lands.

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Step 3.2 - For grid-cells in a geographical entity specified in the land-use change matrix (e.g. a zone in a prefecture), having a land-use type selected in Step 3.1 (e.g. Paddy fields), sort them and calculate cumulative sum of the area of LUC-Unit according to the order of LUC-LI assigned in Step 2. PD: paddy fields.

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Cell ID	Prefecture	City	Agcom [1]	Zone	Soil	Land-use	Cell area	Unit ID	Unit area	LUC-LI	Unit area cum. Sum
50	08	001	301	1	C	PD	1	15	3	1	3
51	08	001	301	1	C	PD	1	15	3	1	3
52	08	001	301	1	C	PD	1	15	3	1	3
304	08	066	210	1	A	PD	1	87	3	2	6
305	08	066	210	1	A	PD	1	87	3	2	6
306	08	066	210	1	A	PD	1	87	3	2	6
9	08	001	102	1	C	PD	1	5	1	3	7
126	08	025	003	1	B	PD	1	213	2	4	9
127	08	025	003	1	B	PD	1	213	2	4	9
...
6	08	001	102	1	B	PD	1	3	1	598	4000
512	08	077	005	1	D	PD	1	462	2	623	4002
513	08	077	005	1	D	PD	1	462	2	623	4002
...

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574 **Step 3.3** - For grid-cells showing values of the cumulative sum of the LUC-Unit less than the area
 575 of land-use conversion for target land-use type as specified in the Step 3.1 (e.g. 4,000 ha of
 576 Paddy fields should be converted), assign new land-use type (e.g. Settlements) based on the
 577 probability of land-use change specified for each land-use change patterns defined in the Step
 578 3.1 with random number generation for uniform distribution of integer ranging from 0 to 100. In
 579 this example, a grid-cell with the assigned random number ranging from 0 to 24 will be assigned
 580 a new land-use type 'upland crop fields (UP)', while those with the random number ranging from
 581 25 to 100 will be assigned 'settlements (ST)'.
 582



Cell ID	Prefecture	City	Agcom [1]	Zone	Soil	Land-use	Cell area	Unit ID	Unit area	LUC-11	Unit area cum. sum	Random number	New land-use
50	08	001	301	1	C	PD	1	15	3	1	3	34	ST
51	08	001	301	1	C	PD	1	15	3	1	3	12	UP
52	08	001	301	1	C	PD	1	15	3	1	3	38	ST
304	08	066	210	1	A	PD	1	87	3	2	6	38	ST
305	08	066	210	1	A	PD	1	87	3	2	6	91	ST
306	08	066	210	1	A	PD	1	87	3	2	6	39	ST
9	08	001	102	1	C	PD	1	5	1	3	7	26	ST
126	08	025	003	1	B	PD	1	213	2	4	9	90	ST
127	08	025	003	1	B	PD	1	213	2	4	9	24	UP
...
6	08	001	102	1	B	PD	1	3	1	598	4000	90	ST
512	08	077	005	1	D	PD	1	462	2	623	4002	-	PD
513	08	077	005	1	D	PD	1	462	2	623	4002	-	PD
...

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586 **Supplementary Material B.** Key quantities on agricultural activity estimated for year 1970-2008
587 and those in future scenarios BAU and MAFF-BP projected toward year 2020

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Table B1. Area of each land-use (employed in simulation), unit: 10³ ha.

Land-use ¹⁾	1970	1980	1990	2000	2008	LUC ²⁾	BAU	MAFF-BP
							2020	2020
01 PD	2,866	2,586	2,139	1,875	1,642		1,512 (92)	1,739 (106)
02 UP	1,453	1,621	1,845	1,806	1,809		1,695 (94)	1,712 (95)
03 OC	611	570	454	347	304		255 (84)	292 (96)
04 MG	505	560	647	630	580		538 (93)	653 (113)
<i>sub-total</i>	<i>5,435</i>	<i>5,337</i>	<i>5,085</i>	<i>4,657</i>	<i>4,335</i>		<i>3,999 (92)</i>	<i>4,395 (101)</i>
05 UG	956	1,024	1,235	1,500	1,537	URB	1,537 (100)	1,537 (100)
						ABN	1,953 (127)	1,557 (101)
06 FL	442	434	393	296	357		357 (100)	357 (100)
07 WL	48	46	38	38	38		38 (100)	38 (100)
08 ST	64	89	153	351	519	URB	854 (165)	458 (88)
						ABN	439 (85)	439 (85)
09 OL	85	100	126	188	245		245 (100)	245 (100)
<i>Total</i>	<i>7,030</i>	<i>7,030</i>	<i>7,030</i>	<i>7,030</i>	<i>7,030</i>	URB	<i>7,030 (100)</i>	<i>7,030 (100)</i>
						ABN	<i>7,030 (100)</i>	<i>7,030 (100)</i>

591 1) PD: paddy; UP: upland fields; OC: orchards; MG: managed grasslands; UG: unmanaged grasslands; FL: forest lands.
592 2) LUC: land-use change scenario. Same area was applied for both URB and ABN land-use change scenarios for PD, UP, OC, MG, FL, WL, and OL.

593
594

Table B2. Amount of plant residue input to fields (employed in simulation), unit: Gg C yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	LUC ²⁾	BAU	MAFF-BP
							2020	2020
01 PD	4,204	3,460	3,923	4,338	3,947		3,410 (86)	4,300 (109)
02 UP	992	1,205	1,425	1,397	1,303		1,173 (90)	1,793 (138)
03 OC	341	331	294	275	252		208 (83)	246 (98)
04 MG	1,231	1,367	1,655	1,592	1,429		1,328 (93)	1,358 (95)
05 UG	3,634	3,891	4,695	5,700	5,841	URB	5,841 (100)	5,841 (100)
						ABN	7,421 (127)	5,916 (101)
06 FL	884	868	787	593	714		714 (100)	714 (100)
<i>Total</i>	<i>11,286</i>	<i>11,122</i>	<i>12,779</i>	<i>13,895</i>	<i>13,486</i>	URB	<i>12,674 (94)</i>	<i>14,252 (106)</i>
						ABN	<i>14,254 (106)</i>	<i>14,327 (106)</i>

595 2) LUC: land-use change scenario.

596
597

Table B3. Number of livestock, unit: 10³ heads.

Livestock		1970	1980	1990	2000	2008	BAU	MAFF-BP
							2020	2020
Dairy cow	milking	888	1,069	1,080	992	862	743 (86)	668 (77)
	heifer, dry	314	355	346	259	213	184 (86)	140 (66)
	U2Y ¹⁾	608	646	605	513	458	395 (86)	396 (86)
Beef cattle	2YO ¹⁾	831	723	854	870	994	1,162 (117)	1,272 (128)
	U2Y ¹⁾	984	743	826	826	829	969 (117)	881 (106)
Pigs	dairy breed	186	716	1,039	1,123	1,067	830 (78)	814 (76)
	fattening	5,667	8,609	10,634	8,807	8,777	8,278 (94)	8,914 (102)
	breeding	844	1,169	1,182	1,000	967	912 (94)	948 (98)
Poultry	hen, 6MO ¹⁾	43	34	40	38	39	41 (105)	39 (100)
	hen, U6M ¹⁾	120	124	138	141	143	130 (91)	136 (95)
	broiler	55	128	151	108	103	106 (103)	106 (103)

598 Numbers in parenthesis presented for 2020 scenarios indicate percentage values compared with those in 2008.

599 1) 2YO: 2 years and older; U2Y: under 2 years old; U6M: under 6 months old; 6MO: 6 months and older.

600 2) Business-As-Usual scenario.

601 3) Ministry of Agriculture, Forestry, and Fishery (2010), Basic Plan on Food, Agriculture and Rural Areas.

602

603 Table B4. Amount of organic carbon in compost, slurry, and excreta from different sources (original estimate), unit: Gg C yr⁻¹.

Sources	1970	1980	1990	2000	2008	BAU	MAFF-BP
						2020	2020
Compost ²⁾	LW	1,775	2,259	2,557	2,317	2,247	2,155 (96) 2,135 (95)
	BD	300	483	512	394	233	172 (74) 173 (74)
	SM	2,992	3,353	3,755	3,382	3,211	2,977 (93) 3,006 (94)
	FW	0	1	4	23	58	59 (102) 59 (102)
	ST	1,279	874	890	535	437	405 (93) 399 (91)
<i>sub-total</i>	<i>6,346</i>	<i>6,970</i>	<i>7,718</i>	<i>6,651</i>	<i>6,186</i>	<i>5,768 (93) 5,772 (93)</i>	
Slurry ^{1,2)}	SL_UP	17	18	18	14	12	10 (83) 13 (108)
	SL_MG	11	17	19	20	19	14 (74) 13 (68)
	<i>sub-total</i>	<i>28</i>	<i>35</i>	<i>37</i>	<i>34</i>	<i>31</i>	<i>24 (77) 26 (84)</i>
Excreta ^{1,2)}	EX_MG	15	21	24	25	25	22 (88) 23 (92)
<i>Total</i>	<i>6,389</i>	<i>7,026</i>	<i>7,779</i>	<i>6,710</i>	<i>6,242</i>	<i>5,814 (93) 5,962 (96)</i>	

604 Numbers in parenthesis presented for 2020 scenarios indicate percentage values compared with those in 2008.

605 LW: livestock waste; BD: bedding for livestock; SM: secondary materials for composting livestock waste; FW: food waste; ST: rice and wheat straw.

606 SL_UP: slurry applied to upland fields; SL_MG: slurry applied to managed grasslands. EX_MG: excreta applied to managed grasslands.

607 1) A conversion factor of 0.5 was applied for above listed values of slurry and excreta prior to determination of the annual input of farm-yard manure in RothC to take account relatively fast decomposition of these organic matters compared to composted manure.

608 2) Values shown in this table were estimated based on agricultural field area data in national statistics and thus were not identical to those listed in Table 5 that used area data from land-use map data applied in simulation.

611 Table B5. Amount of manure applied to fields (employed in simulation), unit: Gg C yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU	MAFF-BP
						2020	2020
01 PD	2,191	1,855	1,138	807	692	561 (81) 772 (112)	
02 UP	3,457	3,763	3,497	2,782	2,457	1,981 (81) 3,067 (125)	
03 OC	577	524	381	398	340	247 (73) 325 (96)	
04 MG	0	727	2,701	2,510	2,336	2,813 (120) 1,298 (56)	
<i>Total</i>	<i>6,225</i>	<i>6,869</i>	<i>7,717</i>	<i>6,497</i>	<i>5,825</i>	<i>5,602 (96) 5,462 (94)</i>	

613 Same amount of manure was applied for both s1 and s2 land-use change scenarios in each land-use type.

614 1) PD: paddy; UP: upland fields; OC: orchards; MG: managed grasslands.

615 Table B6. Amount of slurry applied to fields (employed in simulation), unit: Gg C yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU	MAFF-BP
						2020	2020
02 UP	27	34	36	27	23	25 (109) 24 (104)	
04 MG	37	33	39	39	35	25 (71) 25 (71)	
<i>Total</i>	<i>64</i>	<i>67</i>	<i>75</i>	<i>66</i>	<i>58</i>	<i>50 (86) 49 (84)</i>	

617 Same amount of slurry was applied for both URB and ABN land-use change scenarios in each land-use type.

618 1) CL: croplands; MG: managed grasslands.

619 Table B7. Amount of excreta input to field (employed in simulation), unit: Gg C yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU	MAFF-BP
						2020	2020
04 MG	54	40	47	49	46	43 (93) 44 (96)	

621 Same amount of excreta was applied for both URB and ABN land-use change scenarios.

622 1) MG: managed grasslands.

623 Table B8. Rate of plant residue application to fields, unit: Mg C ha⁻¹ yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU	MAFF-BP
						2020	2020
01 PD	1.5	1.3	1.8	2.3	2.4	2.3 (94) 2.5 (103)	
02 UP	0.7	0.7	0.8	0.8	0.7	0.7 (96) 1.1 (146)	
03 OC	0.6	0.6	0.7	0.8	0.8	0.8 (99) 0.8 (101)	
04 MG	2.4	2.4	2.6	2.5	2.5	2.5 (100) 2.1 (84)	

625 1) PD: paddy; UP: upland fields; OC: orchards; MG: managed grasslands.

626

627 Table B9. Rate of manure application to fields, unit: Mg C ha⁻¹ yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU		MAFF-BP	
						2020		2020	
01 PD	0.8	0.7	0.5	0.4	0.4	(88)	0.4	(105)	
02 UP	2.4	2.3	1.9	1.5	1.4	1.2	(86)	1.8 (132)	
03 OC	1.0	0.9	0.8	1.2	1.1	1.0	(87)	1.1 (100)	
04 MG	0.0	1.3	4.2	4.0	4.0	5.2	(130)	2.0 (49)	

628 1) PD: paddy; UP: upland fields; OC: orchards; MG: managed grasslands.

629
630 Table B10. Rate of overall input of organic carbon (sum of plant residue, manure, slurry, and excreta) to fields, unit: Mg C ha⁻¹ yr⁻¹.

Land-use ¹⁾	1970	1980	1990	2000	2008	BAU		MAFF-BP	
						2020		2020	
01 PD	2.2	2.1	2.4	2.7	2.8	2.6	(93)	2.9 (103)	
02 UP	3.1	3.1	2.7	2.3	2.1	1.9	(90)	2.9 (137)	
03 OC	1.5	1.5	1.5	1.9	2.0	1.8	(92)	2.0 (101)	
04 MG	2.5	3.8	6.8	6.6	6.6	7.8	(118)	4.1 (63)	

631 1) PD: paddy; UP: upland fields; OC: orchards; MG: managed grasslands.

632 **Supplementary Material C.** Equations used to estimate application rate of organic amendments in
 633 agricultural fields

634

635 [Plant residues]

636 **Equations set C.1 (plant residue production for major crops and vegetables);**

637 Annual plant residue inputs to soils in different prefecture and year were estimated for each cropping group using
 638 the following equations;

639 **Equation C.1.1: for rice, wheat, sweet potato, beans, millet, and vegetables;**

$$RSC_{cg,pr,y} = \begin{cases} \sum_{c=1}^{nc_{cg}} (YFW_{c,pr,y}) \cdot YD2F_{cg} \cdot RS2Y_{cg} \cdot RSINC_{cg,rg,y} \cdot RSCC_{cg} \\ \sum_{c=1}^{nc_{cg}} (YFW_{c,pr,y} \cdot YD2F_c \cdot RS2Y_c) \cdot RSINC_{cg,rg,y} \cdot RSCC_{cg} \end{cases}$$

640 **Equation C1.2: for orchards, manure crops, and forage;**

$$RSC_{cg,pr,y} = \sum_{c=1}^{nc_{cg}} (RSCA_{c,y} \cdot CA_{c,pr,y}) \cdot RSINC_{cg,rg,y} \cdot RSCC_{cg}$$

641 Equation C1.2.1: orchards;

$$RSCA_{c,y} = const_c$$

642 Equation C1.2.2: manure crops;

643 for crops other than grass,

$$RSCA_{c,y} = BMCA_c$$

$$BMCA_c = YDWCA_c \cdot (1 + BG2Y_c)$$

$$YDWCA_c = const_c$$

644 for Italian ryegrass,

645 See Equation C1.2.3.

646 for grass excluding Italian ryegrass (including mixed seeding of *Poaceae* and *Fabaceae*),

647 See Equation C1.2.4.

648

649 Equation C1.2.3: forage of Italian ryegrass;

$$RSCA_{GRIR,y} = RSBGCA_{GRIR,y}$$

$$RSBGCA_{GRIR,y} = RSBGCA_{GRP,1982-84} \cdot \frac{YFW_{GR,y}}{YFW_{GR,1983}}$$

650 Equation C1.2.4: forage of grass excluding Italian ryegrass (including mixed seeding of *Poaceae* and
 651 *Fabaceae*);

$$RSCA_{GRNI,y} = (RSBGCA_{GR,y} + RSUGCA_{GR,y}) + \frac{BMCA_{GR,y}}{YRRE}$$

$$RSBGCA_{GR,y} = RSBGCA_{GRP,1982-84} \cdot \frac{YFWCA_{GR,1997-2005}}{YFWCA_{GRP,1997-2005}} \cdot \frac{YFWCA_{GR,y}}{YFWCA_{GR,1996}}$$

$$RSUGCA_{GR,y} = RSUGCA_{GRP,1982-84} \cdot \frac{YFWCA_{GR,1997-2005}}{YFWCA_{GRP,1997-2005}} \cdot \frac{YFWCA_{GR,y}}{YFWCA_{GR,1996}}$$

$$YFWCA_{GR,1997-2005} = \sum_{y=1997}^{2005} \left(\frac{YFWCA_{GRP,y} \cdot CA_{GRP,y} + YFWCA_{GRPF,y} \cdot CA_{GRPF,y}}{CA_{GRP,y} + CA_{GRPF,y}} \right) / 9$$

$$BMCA_{GR,y} = YDWCA_{GR,1996} \cdot (1 + BG2Y_{GR}) \cdot \frac{YFWCA_{GR,y}}{YFWCA_{GRPF,1996}}$$

$$YDWCA_{GR,1996} = \frac{YDWCA_{GRPF,1996} \cdot CA_{GRPF,1997-2005} + YDWCA_{GRP,1996} \cdot CA_{GRP,1997-2005}}{CA_{GRPF,1997-2005} + CA_{GRP,1997-2005}}$$

652

653 where,

654 RSC = mass of organic carbon in plant residue to be incorporated into soils in a year, Mg C yr⁻¹.

655 *c* = cropping type (e.g. tomato, two-row barley, Italian ryegrass, etc.).

656 *cg* = cropping group (e.g. paddy rice, wheat, vegetables, forage and manure crop, etc.).

657 *nc* = the number of cropping types in a cropping group (paddy rice (3); wheat (4); sweet potato (1); beans (4);

658 millet (1); vegetables (38); forage and manure crop (8); industrial crop (3); fruit and tea (2)).

659 *ncg* = the number of cropping groups in a land-use type (paddy fields (3); upland fields (7); orchards (1);

660 managed grasslands (1)).

661 *pr* = prefecture.

662 *rg* = region (group of prefectures).

663 *y* = year.

664 *const* = fixed constant taken from literatures.

665 YFW = yield in fresh weight, Mg yr⁻¹.

666 YD2F = proportion of dry weight against fresh weight of yield.

667 RS2Y = proportion of residues by weight against yield, dry weight basis.

668 RSINC = proportion of plant residues to be returned to soils against other usages or treatments such as bedding

669 for live-stock, handicraft, incineration, and disposal.

670 RSCC = concentration of organic carbon in plant residue, dry matter basis, g g⁻¹.

671 CA = cropping area, ha.

672 RSCA = plant residue production per a unit cropping area in a year, Mg ha⁻¹ yr⁻¹.

673 BMCA = total biomass of grass including above and below ground biomass per unit cropping area, Mg ha⁻¹.
 674 YDWCA = yield per a unit cropping area in a year in dry weigh, Mg ha⁻¹ yr⁻¹.
 675 YFWCA = yield per a unit cropping area in a year in dry weigh, Mg ha⁻¹ yr⁻¹.
 676 BG2Y = proportion of below ground biomass against yield in dry weight.
 677 RSBGCA = below ground biomass residue input to soils per a unit cropping area in a year, Mg ha⁻¹ yr⁻¹.
 678 RSUGCA = upper ground biomass residue input to soils per a unit cropping area in a year, Mg ha⁻¹ yr⁻¹.
 679 YRRE = mean of number of years for renewal of grasslands.
 680 GR = grass.
 681 GRIR = Italian ryegrass.
 682 GRNI = grass excluding Italian ryegrass.
 683 GRP = grass of *Poaceae* family, e.g. Italian ryegrass.
 684 GRPF = grass with mixed seeding of *Poaceae* and *Fabaceae* families.

685
 686 **Equation C.1.3 (plant residue input to soil in different land-use types);**

$$RSCI_{lu,pr,y} = \sum_{cg=1}^{n_{cg,lu}} (RSC_{cg,pr,y}) / A_{lu,pr,y}$$

687 where,

688 RSCI = annual rate of plant residue organic carbon input to soils, Mg C ha⁻¹ yr⁻¹.

689 *lu* = land-use type, including paddy fields, upland fields, orchards, and managed grasslands.

690 *pr* = prefecture.

691 *y* = year.

692 *cg* = cropping group (e.g. paddy rice, wheat, vegetables, forage and manure crop, etc.).

693 *n_{cg}* = the number of cropping groups in a land-use type (paddy fields (3); upland fields (7); orchards (1);
 694 managed grasslands (1)).

695 A = area of field in each land-use type, ha.

696
 697 **Table C1** List of parameters used for estimation for production and application of plant residues.

crop group	YD2F ¹⁾	RSCA ²⁾	RS2Y ³⁾	RSINC ⁴⁾	BMCA ⁵⁾	YRRE ⁶⁾	RSCC ⁷⁾
rice (1)			1.20	0.32-0.64-0.95			
straws							
husks	0.85		0.22	0-0.20-0.35			
roots & stables			0.27	1.0			
wheat (4)	0.85		0.97	0-0.63-1.0			
shoots							
roots & stables			0.42	1.0			
sweet potato (1)	0.30		0.50	0.46			0.4
beans (4)	0.85-0.90		0.9-1.0	0.75			
millet (1)	0.85		1.50	0.46			
vegetables (29)	0.05-0.25		0.2-5.0	0.46			
orchards (18)		1.0-15.4		1.0			
forage & manure crops (9)		3.6-15.9		1.0	5.6-17.2	10	

698 Two values separated with hyphen indicate minimum and maximum values, whereas three values separated with two hyphens indicate minimum,
 699 mean, and maximum values of parameter.

700 1) YD2F: proportion of dry weight against fresh weight of yield.

- 701 2) RSCA: proportion of residues by weight against yield, dry weight basis.
702 3) RS2Y: proportion of residues by weight against yield, dry weight basis.
703 4) RSINC: proportion of plant residues to be returned to soils against other usages or treatments such as bedding for live-stock, handicraft,
704 incineration, and disposal.
705 5) BMCA: total biomass including both above and below ground biomass per unit cropping area, Mg ha⁻¹.
706 6) YRRE: mean of number of years for renewal of grasslands.
707 7) RSCC: concentration of organic carbon in plant residue, dry matter basis, g g⁻¹. Parameter value was taken from Shirato et. al. (unpublished).

708

709

710 [Live-stock waste compost]

711 **Equation C.2.1 (Live-stock waste);**

$$LWFW_{ls,pr,y} = \sum_{lss=1}^{nlss_{ls}} (LSN_{lss,pr,y} \cdot LWE_{lss} \cdot DN_y)$$

712 where,

713 *ls* = live-stock type, including dairy cattle, beef cattle, swine, hen, and broiler.

714 *pr* = prefecture.

715 *y* = year.

716 LWFW = mass of live-stock waste produced in a year, in fresh weight, Mg y⁻¹

717 LSN = the number of head of live-stock

718 LWE = rate of emission of live-stock waste (excrement) in fresh weight per a head of live-stock, kg d⁻¹ head⁻¹

719 DN = the number of days in a year

720 *lss* = live-stock sub-category, based on class of age or utilization

721 *nlss* = the number of live-stock sub-category in different live-stock types (dairy cattle (3); beef cattle (3); swine
722 (2); hen (2); broiler (1))

723

724 **Equation C.2.2 (Live-stock waste to be utilized for composting, in different type of live-stock);**

$$LW4LC_{ls,pr,y} = LWFW_{ls,pr,y} \cdot LWCOMP_{ls}$$

$$LW4SL_{ls,pr,y} = LWFW_{ls,pr,y} \cdot LWSL_{ls}$$

725 where,

726 LW4LC = mass of live-stock waste to be utilized for composting (to produce LWC)

727 LW4SL = mass of live-stock waste to be utilized for slurry production (to produce LWC)

728 *ls* = live-stock type, including dairy cattle, beef cattle, swine, hen, and broiler.

729 *pr* = prefecture.

730 *y* = year.

731 LWFW = mass of live-stock waste produced in a year, in fresh weight, Mg y⁻¹

732 LWCOMP = proportion of live-stock waste to be utilized for composting against other usages.

733 LWSL = proportion of live-stock waste to be utilized for slurry production against other usages.

734

735 **Equation C.2.3 (Live-stock waste to be utilized for composting, sum of all types of live-stock);**

$$\begin{aligned} \text{LWC}_{pr,y} &= \sum_{ls=1}^{nls} (\text{LW4LC}_{ls,pr,y} \cdot \text{LWD2F}_{ls} \cdot \text{LWDC}_{ls} \cdot \text{LWCC}_{ls}) \\ \text{SLC}_{pr,y} &= \sum_{ls=1}^{nls} (\text{LW4SL}_{ls,pr,y} \cdot \text{LWD2F}_{ls} \cdot \text{LWCC}_{ls}) \end{aligned}$$

736 where,

737 LWC = mass of organic carbon in live-stock waste compost derived from live-stock waste produced in a year in
738 dry weight, Mg C y⁻¹.

739 SLC = mass of organic carbon in slurry derived from live-stock waste produced in a year in dry weight, Mg C
740 y⁻¹.

741 *pr* = prefecture.

742 *y* = year.

743 *ls* = live-stock type, including dairy cattle, beef cattle, swine, hen, and broiler.

744 *nls* = number of live-stock types.

745 LW4LC = mass of live-stock waste to be utilized for composting (to produce LWC)

746 LW4SL = mass of live-stock waste to be utilized for slurry production (to produce LWC)

747 LWD2F = proportion of dry weight against fresh weight of live-stock waste (excrement)

748 LWDC = residual ratio of live-stock waste after decomposition during composting.

749 LWCC = concentration of organic carbon in live-stock waste in dry weigh basis, g g⁻¹.

750

751 **Equation C.2.4 (secondary materials to be utilized for live-stock waste compost production);**

$$\text{SMC}_{pr,y} = \sum_{sm=1}^{nsm} (\text{LWCOMP}_{pr,y} \cdot \text{SM2LW}_{sm} \cdot \text{SMD2F}_{sm} \cdot \text{SMDC}_{sm} \cdot \text{SMCC}_{sm})$$

752 where,

753 SMC = mass of organic carbon in live-stock waste compost derived from secondary materials produced in a
754 year, Mg C y⁻¹

755 *pr* = prefecture.

756 *y* = year.

757 *sm* = secondary material type, including straw, husks, saw-dust, and bark.

758 *nsm* = number of secondary materials to be used for composting live-stock waste.

759 LWCOMP = proportion of live-stock waste to be utilized for composting against other usages.

760 SM2LW = proportion of applied secondary materials against live-stock waste during composting, based on
761 survey data.

762 SMD2F = proportion of dry weight against fresh weight of secondary materials for live-stock waste
763 composting.

764 SMDC = residual ratio of secondary materials used for live-stock waste composting after decomposition during
765 composting.

766 SMCC = concentration of organic carbon in secondary materials, g g^{-1} .

767

768 **Equation C.2.5 (bedding materials for live-stock farming used for live-stock waste composting);**

$$\text{BDC}_{pr,y} = \sum_{bd=1}^{nbd} \left\{ \left(\sum_{ls=1}^{nls} \text{LSN}_{ls} \cdot \text{BD2LS}_{bd,ls} \right) \cdot \text{BDD2F}_{bd} \cdot \text{BDDC}_{bd} \cdot \text{BDCC}_{bd} \right\}$$

769 where,

770 BDC = mass of organic carbon in live-stock waste compost derived from bedding materials for live-stock, Mg
771 yr^{-1} .

772 bd = bedding materials for live-stocks, including rice-straw, saw-dust, wheat straw, dry grass, hey, and others.

773 nbd = number of bedding materials for live-stocks.

774 ls = type of live-stock, including dairy cattle, beef cattle, swine, hen, and broiler.

775 nls = number of types of live-stock

776 LSN = the number of head of live-stock.

777 BD2LS = mass of bedding materials to be applied per a head of live-stock, based on survey data, Mg head^{-1}
778 yr^{-1} .

779 BDD2F = proportion of dry weight against fresh weight of bedding materials.

780 BDDC = residual ratio of bedding materials after decomposition during composting.

781 BDCC = concentration of organic carbon in bedding materials, g g^{-1} .

782

783 **Equation C.2.6 (food waste to be utilized for composting);**

$$\text{FWC}_{pr,y} = \sum_{fi=1}^{nfi} \left(\text{FWCOMP}_{fi,jp,y} \cdot \frac{\text{PN}_{pr,y}}{\text{PN}_{jp,y}} \right) \cdot \text{FWD2F} \cdot \text{FWDC} \cdot \text{FWCC}$$

784 where,

785 FWC = mass of organic carbon in compost derived from food waste in a year, Mg yr^{-1} .

786 pr = prefecture.

787 y = year.

788 fi = food industry, including manufacturing, wholesale business, retailing, and foodservice.

789 nfi = number of food industry

790 jp = Japan.

791 FWCOMP = mass of food waste to be utilised for composting in fresh weight, Mg yr^{-1} .

792 PN = human population in a geographic administrative entity (prefecture or country).

793 FWD2F = proportion of dry weight of food waste against fresh weight.

794 FWDC = residual ratio of food waste after decomposition during composting.

795 FWCC = concentration of organic carbon in food waste, g g⁻¹.

796

797 **Equation C.2.7 (mass of organic carbon in live-stock waste compost produced in a year);**

$$LCC_{pr,y} = LWC_{pr,y} + SMC_{pr,y} + BDC_{pr,y} + FWC_{pr,y}$$

798 where,

799 LCC = mass of organic carbon in live-stock waste compost produced in a year, Mg yr⁻¹.

800 *pr* = prefecture.

801 *y* = year.

802 LWC = mass of organic carbon in live-stock waste compost derived from live-stock waste produced in a year in
803 dry weight, Mg C yr⁻¹.

804 SMC = mass of organic carbon in live-stock waste compost derived from secondary materials produced in a
805 year, Mg C yr⁻¹.

806 BDC = mass of organic carbon in live-stock waste compost derived from bedding materials for live-stock
807 produced in a year, Mg C yr⁻¹.

808 FWC = mass of organic carbon in live-stock waste compost derived from food waste produced in a year, Mg C
809 yr⁻¹.

810

811 **Equation C.2.8 (mass of live-stock waste compost applied to soils in different land-use in a year, except
812 managed grasslands);**

813

$$LCC_{lu,pr,y} = \sum_{cg=1}^{ncglu} (LCI_{cg,pr,y} \cdot CA_{cg,pr,y} \cdot FRT_{cg,lu} \cdot LCD2F \cdot LCCC)$$

814 where,

815 LCC = mass of organic carbon in live-stock waste compost applied to soils in all land-use types in a year, Mg C
816 yr⁻¹.

817 *lu* = land-use types, including paddy fields, upland fields, and orchards.

818 *pr* = prefecture.

819 *y* = year.

820 *cg* = cropping group.

821 *ncg* = number of cropping group.

822 LCI = rate of annual live-stock waste compost application to soil, based on questionnaire to farmer, in fresh
823 weight, Mg C ha⁻¹ yr⁻¹.

824 CA = cropping area, ha

825 FRT = fraction of cumulative cropping area in a year to field area (times of rotation in a year)

826 LCD2F = proportion of dry weight of live-stock waste compost against fresh weight.

827 LCCC = concentration of organic carbon in live-stock waste compost, g g⁻¹.

828

829 **Equation C.2.9 (mass of organic carbon in live-stock waste compost applied to soils in managed**
830 **grasslands);**

$$LCC_{MG,pr,y} = LCC_{pr,y} - \sum_{lu=1}^{nlu} LCC_{lu,pr,y}$$

831 where,

832 LCC_{MG} = mass of organic carbon in live-stock waste compost applied to soils in managed grasslands, Mg C yr⁻¹.

833 *pr* = prefecture.

834 *y* = year.

835 *lu* = land-use types, including paddy fields, upland fields, and orchards.

836 *nlu* = number of land-use types, including paddy fields, upland fields, and orchards.

837

838 **Equation C.2.10 (input of live-stock waste compost to soils);**

$$LCCI_{lu,pr,y} = LCC_{lu,pr,y} / A_{lu,pr,y}$$

839 where,

840 LCCI = rate of application of organic carbon in live-stock waste compost to soils per unit area of fields, Mg C

841 ha⁻¹ yr⁻¹.

842 *lu* = land-use types, including paddy fields, upland fields, orchards, and managed grasslands.

843 *pr* = prefecture.

844 *y* = year.

845 LCC = mass of organic carbon in live-stock waste compost applied to soils, Mg C yr⁻¹.

846 A = area of fields, ha.

847