Appendix B. Economic modelling of residual generation for the Lingayen Gulf watershed

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Introduction

Political Boundaries

The Lingayen Gulf watershed crosses four provinces in three political regions (Figure 1, main report). For the study of inland influences on the coastal waters of Lingayen Gulf, emphasis is placed on the provinces and regions that are adjacent to Lingayen Gulf proper.

Lingayen Gulf has an area of 2610 km^2, and a coastline 160 km long. It is bordered by 18 coastal municipalities, 11 in the province of Pangasinan and 7 in the province of La Union. Pangasinan Province consists of another 37 inland municipalities, while La Union has an 13 other municipalities, five of which are coastal but north of Lingayen Gulf, and 8 of which are inland. These two provinces form an envelope around the Gulf. The furthest distance from shoreline to provincial boundary is approximately 60 km.

Pangasinan and La Union are a part of the political Region 1, which also consists of the provinces of Ilocos Norte and Ilocos Sur. The Ilocos provinces are not adjacent to Lingayen Gulf, and are not a part of the Gulf's watershed. Other provinces overlapping the Lingayen Gulf watershed are Tarlac in Region 3, and Benguet in the Cordillera Autonomous Region.

For most descriptive purposes, and for most of the rapid assessment model of residual generation, attention is directed to Pangasinan and La Union provinces, based on the expectation that these more proximal areas generate the majority of inland influences in the Gulf. For the purposes of the input-output model of residual generation, data constraints require the inclusion of all of Region 1.

Human Resources

1. Population/Demographics

As of 1995, there were 2,775,854 people living in Pangasinan and LaUnion, with 2,178,412 in Pangasinan, and 597,442 in LaUnion. This reflects a population growth for the two provinces of 8% between 1990-95, and 23% from 1980-90. The national population growth for 1990-1995 was 13%, and 26% for 1980-1990. The two provinces experienced a slight overall out-migration of 13,000 (about 5 persons/1000) from 1990 to 1995. This reflects a trend of decreasing emigration rates since 1975. The emigration rate from 1975-1980 was 20 persons per thousand, and for 1985-1990, 11 persons per thousand. It should be noted, however, that the coastal towns within the coastal municipalities have experienced a rather large population growth, approximately 13% between 1985-1988. The extent to which this growth is due to immigration from within the provinces or from other regions is not certain.

Population density for the two provinces was 404 persons/km^2 in 1995, 374 persons/km^2 in 1990, and 304 persons/km^2 in 1980. Pangasinan and La Union provinces rank 7th and 8th out of 70 provinces nation-wide in terms of population density. Municipal population densities in 1995 ranged from 70 persons/km to 2200 persons/km. As of 1990, 42% of the population lived in urban areas, as opposed to 28 in 1980. The 1990 level is slightly greater than the regional urbanization level of 36.6%. The urbanization rate for the region has increased significantly since 1960. Between 1960 and 1970 the annual rate of increase was 0.97%. The rate increased to 2.04% from 1970-1980, and to 4.30 from 1980-1990.

2. *Labor Force*

In 1995 the potential labor force (age 15 years and above) was 1,822,000, or 65.64 % of the total population. The labor force participation rate was 58% of potential workers. The 1997 unemployment rate was 10%, while the visible underemployment rate was also 10% for 1997. These numbers have remained fairly steady since the mid-1980's. These figures demonstrate a general trend of under-utilized labor, which is also reflected in the family income statistics. The trend in under-utilized labor is expected to continue as population continues to grow. The manufacturing sector has lagged in labor absorption due to policies favoring inward-looking capital intensive industrialization (Medalla et al., 1992). This leaves agriculture and service sectors as the primary source of labor absorption. In the past, agriculture had been able to absorb the expanding labor force, but there is no longer much room for expansion of agricultural lands. It has been left to the low productivity informal service sector to absorb much of the increasing labor force.

3. Incomes

The average family income for 1995 was P 68376 per year (approximately U. S. $2,600). In 1991, roughly 60% of families had *per capita* incomes below the poverty threshold.

With the low level of industrialization, and with a strong population growth rate, the trend of labor absorption in the low productivity, low wage range is likely to continue. One implication is that, with limited revenue sources, it is unlikely that local governments will be able to effectively address problems of waste disposal in the near future.

Economic Activity

A. Manufacturing

Industrial development in the study area is rather low. As of 1994, over 95% of roughly 5000 manufacturing firms were of the 'cottage industry' type, with fewer than 10 employees. Only 13 firms employed more than 100 workers.

The major industries in the study area include two gin bottling plants, 3 soft drink bottling plants, a fruit and vegetable processing plant, 16 sizeable rice noodle manufacturing firms, and a galvanized iron sheet manufacturing plant.

B. Agriculture

As of 1990, there were 209,473 farms in the study area covering a total of 235,554 hectares, which is 34% of the total land area. Palay (rice) covered about 88% of the total agricultural area, corn 2%, livestock and poultry farms 1.5% . The study area is a major producer of livestock - Pangasinan Province has the largest livestock population in the country. Total livestock population in the study area was 740,000 head of cattle and 3.6 million head of poultry in 1993.

The agricultural land frontier has essentially been reached. Further increases in production will need to rely on improvements in technology and infrastructure, and increased irrigation capacity. A dam is currently under construction near the headwaters of the Agno River that is expected to substantially increase the potential for irrigation.

C. Capture Fisheries

Lingayen Gulf is the major fishing ground for northwest Luzon, providing roughly 1.5% of the Philippine fish supply. It also provides for over 50% of the livelihood of coastal village residents (Padilla et al., 1997). The fishing grounds are essentially open access, and are considered overfished. Maximum sustainable yield is estimated to be roughly 18,000 t/year (Padilla and Morales, 1997). Maximum production was 24,015 t in 1987. By 1995 it was down to 13,443 t, despite an increase in standardized aggregate effort of over 150%.

D. Aquaculture

In 1993 aquaculture accounted for about 60% of the total Lingayen Gulf fish harvest. Just over 50% of the aquaculture harvest came from brackish water fishponds, and oyster farms account for almost 40% of total harvest. Recently, fish-cage culture has become quite popular, although it has experienced some early setbacks due to storm damage. Production data for fish-cage operations has not yet become available.

Land Use

The combined provinces of Pangasinan and La Union occupy 686,127 hectares. Of this amount, 77% is classified as alienable and disposable (available for private ownership, whether industrial, residential, or agricultural). Agriculture occupies 34% of the land area, with 93% of agricultural land devoted to temporary crops, primarily rice. About 5% of the agricultural land is devoted to permanent crops, and the remaining 2% to livestock.

Approximately 23% of the land area is designated as some type of forestland, although the extent of effective forest cover is uncertain due to substantial encroachment upon these areas.

Built-up urban areas cover 28,800 hectares, or 4.2% of the total land area.

<u>Residual Generation Models</u>

One of the important questions raised by LOICZ is how will a change in economic activity affect the flow of residuals (C, N, P, SS) into coastal waters? In order to meet the objectives of LOICZ, a methodology is needed that is generally applicable and available across a wide variety of sites. For many of these sites data is scarce in a number of areas. With these factors in mind, we begin with rather simple models. For site specific purposes, these models may be expanded upon as data allows.

A regional economic activity model may be used to estimate the generation of residuals (James 1985). In its simplest form, residual discharges are given as

1) $r = CX$

where r = a matrix of residual discharges (residual type by economic activity)
C = a matrix of residual discharge coefficients
with c_{kj} = the quantity of residual k per unit of sectoral activity j
X = a diagonal matrix of sectoral activity levels.

Total discharges of each residual type are then given by

2) $R = rS = CX$

where R = a vector of residuals by type (summed across all activities)
S = a summation vector.

So each element of the column vector R represents the sum of the corresponding row in the r matrix. That is, the total discharge of residual type k is the sum of each activity's discharge of residual k.

In the above formulation, X is simply an exogenous estimation of output for each activity in the region. The model may be expanded by allowing economic activity to be represented by a regional input-output model. In such a model, production (X), or supply, is equated to the sum of intermediate (inter-industry) demand (AX) and final demand (Y):

3) $X = AX + Y$

with $A = [a_{ij}]$ where a_{ij} is the Leontief IO technical coefficient and

3a) $a_{ij} = z_{ij} / X_j$, where z_{ij} is the monetary value of the input flow from sector i to sector j

Manipulation of equation 3 yields

4) $X = (I - A)^{-1} Y$

where $(I - A)^{-1}$ represents the Leontief inverse matrix.

Substituting equation 4 into equation 2 gives

5) $R = C (I - A)^{-1} Y$

The total change in residual generation brought about by a change in one or more components of final demand are determined by

6) $\Delta R = C (I - A)^{-1} \Delta Y$

Using equation 4, equation 6 may be rewritten as

7) $\Delta R = C \Delta X$

Equation 7 may be used when analyzing the impact of growth in sectoral production or GDP.

In equations 5–7, matrix R represents the amount of residuals generated during both direct activities and the indirect "support" activities. For example, if fish aquaculture is the direct activity being addressed, agricultural activity may be considered an indirect or support activity, since aquaculture feeds are often derived from agricultural output. Thus, an increase in aquaculture may increase nitrogen loading into coastal waters not only from the application of feeds, but also via the increased use of fertilizers in the agricultural sector.

Equations 2 and 5–7 represent two alternative but related approaches to addressing the question of how economic activity affects the generation of residuals. Equations 5–7 represent the input-output (IO) modeling approach discussed during the December 1997 Bolinao workshop (LOICZ, 1997). Equation 2 represents the rapid assessment (RA) method utilized by WHO (1993), which may readily be incorporated into a geographical information systems (GIS) modelling approach such as that discussed in Turner et al. (1997).

Each approach has its strengths and weaknesses. A favorable aspect of the IO approach is that it captures the interrelationships between sectors of the economy. A change in activity of one sector typically requires changes in activity in other sectors. These interrelations are not captured in the RA modelling approach, and thus may lead to an underestimate of residual discharges. On the other hand, data constraints typically require a considerable degree of aggregation of economic sectors in regional IO models. An RA/GIS model allows for a considerable degree of disaggregation, and allowance for consideration of spatial relationships. These relationships may be of particular importance when taking account of environmental assimilation of residuals.

It should be noted that the IO model by itself does not represent an integrated ecological-economic model. It is when the IO model output is combined with the biogeochemical model as an input that a step toward integration in a 'weak' sense, in which "each discipline continues to use and refine its own paradigm, appropriate to the system it studies, but in which they together create combined models of the interactions between the two systems" (Russell 1996), occurs. Theoretically, this integration could be expanded if the outputs of the biogeochemical model (that is, some measure of water quality) could be incorporated in dose-response relationships that quantify the impact of changing water quality on habitats that affect, for example, fisheries or tourism. Thus far, obtaining such dose-response relationships has proven to be problematic.

IO Model

During the 1997 SWOL workshop in Bolinao, it was decided that each country should attempt to create an 11-sector regional IO model, preferably with an endogenized household sector as a twelfth sector. The Philippine study's approach to this objective was to create a 30-sector regional model based upon the 229-sector 1994 national model, adjusted with the simple location quotient method of reduction. This 30-sector model was then aggregated to the agreed upon 12-sector model. The sectors for the 30-sector model and their aggregation to 12 sectors are shown in Table B1.

Table B1. Sectoral Classification Scheme (Region 1 - Ilocos Region I/O Table)

Production Sectors			
11 Sector Regional I/O Table			30-Sector National I/O Table
Code	Description	Code	Description
1	Agriculture	01 02 03	Agricultural crops Livestock and poultry Agricultural services
2	Fishery	04	Fishery
3	Forestry	05	Forestry
4	Mining and quarrying	06	Mining & quarrying
5	Manufacturing I	07 08 09 10 11 12 13 14 15	Meat, meat products, dairy products Milled rice and corn; flour; bakery products Fish preparations Miscellaneous food manufactures Beverage industries Tobacco manufactures Textile and textile products, leather & leather products Wood and wood products; furniture and fixtures Paper and paper products; publishing and printing
6	Manufacturing II	16 17 18 19 20 21	Chemical products; rubber and plastic products Products of petroleum and coal Non-metallic mineral products Basic metals Fabricated metal products; machinery and transport equipment Miscellaneous manufactures
7	Electricity, gas & water	23	Electricity, gas and steam
8	Waterworks and supply	24	Waterworks and supply
9	Construction	22	Construction
10	Transportation, communication & storage	26	Transportation, storage and communication
11	Other Services	25 27 28 29 30	Wholesale and retail trade Finance, insurance and real estate Hotel and restaurant services Other private business, personal and community services Government services

<u>Highlights Of The Input-Output Model Components</u>

This section gives a brief description of the development and the components of an IO model. The discussion will refer to the 11-sector model, with the appropriate tables referred to as ‘Table B_a’. The corresponding 12 sector model (households endogenized) tables will also be provided, as ‘Table B_b’.

Table B_2a is the 1994 regional 11 x 11 sector IO table for Region 1 of the Philippines. The upper portion (rows 1–11 and columns 1–11, collectively referred to as the production sector) of the table shows the inter-industry flow of goods. Such an inter-industry transactions table is derived from a larger set of income and production accounts for a region (see Annex A).

Each element of the transactions table (the z_{ij} terms of equation 3a, expressed in monetary units) represents the sale (supply) of sector i’s outputs to sector j for use as inputs to j’s production process. Thus, by reading row 1 it is seen that sector 1 supplies an amount 2399734 to sector 1 (itself), 200 to sector 2, 20 to sector 3, etc.

Reading the columns tells us the amount each sector purchases (demands) from all other sectors. Thus sector 2 demands (or buys) an amount 200 from sector 1, 149876 from itself, 0 from sector 3, etc.. . Such demand of one production sector for the output of other producing sectors for use as inputs is termed intermediate demand, and is represented by the ‘AX’ vector in equation 3.

One interpretation of Table B2a is that it is an account of the amounts that each sector demands from other sectors in order to satisfy their own production processes. That is, the inter-industry transactions table (in particular, the columns) represents intermediate demands. The values for the AX vector are determined by summation of each row sector. Thus, the right-most column of Table B2a, labeled Total Intermediate Demand, is the AX column vector of equation 3. The column sum of each production sector is termed Total Intermediate Inputs.

Table B2a. 11 Sector transaction table (Region 1 - Ilocos Region 1994, in thousand pesos).

Code	1	2	3	4	5	6	7	8	9	10	11
1	2399734	200	20	0	321644	29426	0	0	0	0	98986
2	355	149876	0	2	24348	58	0	0	0	0	49333
3	0	0	198	3434	11515	3655	578	2	1300	1	1
4	424	26	0	0	298	250847	1719	0	225440	19	1591
5	1012232	178397	15	18169	580905	250994	746	262	357665	6455	719863
6	1590268	252689	1964	189395	307513	1675043	132909	5289	3373165	730750	1126510
7	141534	26811	47	4900	81811	303896	10479	4745	101783	38259	621418
8	4365	0	0	43	11752	181	0	0	11383	7522	85954
9	6431	11332	24	12449	24846	64531	4788	1579	309322	59068	955612
10	354229	57705	1028	12837	86840	132922	0	478	592956	60972	776879
11	743945	62340	677	49014	302584	397675	40736	2932	995823	449427	2545190
TII	15534477	1745729	19136	533221	2218032	3581592	275516	27653	7273300	2241890	18924333
CE	6193676	519231	2238	172568	262166	472340	83561	12366	1283941	618778	9740618
GOS	11275152	1638678	12941	478260	1050157	1665280	187065	16110	2433073	1077484	11945510
HOA	3087284	487122	12925	70410	201810	24	0	0	20522	270639	2350698
NHOA	8187868	1151556	16	407850	848347	1665256	187065	16110	2412551	806845	9594812
TPI	17468828	2157909	15179	650828	1312323	2137620	270626	28476	3717014	1696262	21686128
TI	23722345	2897285	19152	941071	3066379	5246848	462581	43763	9685851	3048735	57335230

Table B2a can be expanded in a variety of ways. First, there are inputs to the production process that must be paid for other than those produced by other industries. The primary example of these value-added items is employee compensation. For the purposes of this model, other categories are lumped together under operating surpluses. This collection of inputs is known as the payments, or value-added sector.

Table B2b. 12 Sector Transaction Table (Sector 1 - Ilocos Region 1994, in thousand pesos)

Code	DESCRIPTION	1	2	9	10	11	12	TID	
									Note:
1	Agriculture	2399734	200	0	0	98986	2390321	2850010	*TII: Total Intermediate Inputs*
2	Fishery	355	149876	0	0	49333	1753267	223972	*CE: Compensation of Employees*
3	Forestry	0	0	1300	1	1	0	20684	*GOS: Gross Operating Surplus*
4	Mining and quarrying	424	26	225440	19	1591	0	480364	*HOA: Household-Operated Activities*
5	Manufacturing I	1012232	178397	357665	6455	719863	19751759	3125703	*NHOA: Non-Household Operating Activities*
6	Manufacturing II	1590268	252689	3373165	730750	1126510	5347774	9385495	*GOS = HOA + NHOA*
7	Electricity, gas and water	141534	26811	101783	38259	621418	1329913	1335683	*TPI: Total Primary Inputs*
8	Waterworks and supply	4365	0	11383	7522	85954	238703	121200	*TPI = CE + GOS*
9	Construction	6431	11332	309322	59068	955612	75468	1449982	*TI: Total Inputs*
10	Transpo., comm., and storage	354229	57705	592956	60972	776879	4708613	2076846	*TI = TII + TPI*
11	Other Services	743945	62340	995823	449427	2545190	19915057	5590343	
12	Household sector	9280960	1006353	1304463	889417	12091316	0	25862917	
TII	Total Intermediate Inputs	15534477	1745729	7273300	2241890	18924333	55510875	52523199	
GOS	Gross Operating Surplus	8187868	1151556	2412551	806845	19189624	0	25278276	
NHOA	Non-HH Operated Activities	8187868	1151556	2412551	806845	19189624	0	25278276	
TPI	Total Primary Inputs	8187868	1151556	2412551	806845	19189624	0	25278276	
TI	Total Inputs	23722345	2897285	9685851	3048735	57335230	55510875	77801475	

A second point of expansion for Table B2a is to include the final demand sectors (see Table B3a). Final demands are demands derived from sources outside the production sector of the region. Examples of final demand sectors would include personal consumption expenditures of households (PCE), government consumption expenditures (GCE), business investment (gross fixed capital formation, GFCF), and net exports (E-M) to other regions. An adjustment for changes in stock inventory (CS) is also be included. Final demands are summed across rows to give the Total Final Demand column vector (TFD in Table B3a), denoted as 'Y' in equation 3. Adding the intermediate and final demand column vectors gives the total output (TO) column vector (the right-most column of Table B3a, for sectors 1-11), denoted as ‘X’ in equation 3.

Table B3a. 11 Sector Transactions Table (Region 1 - Ilocos Region 1994, in thousand pesos)

Code	PCE	GCE	GFCF	CS	E - M	TFD	TO
1	2390321	0	1983520	177951	16320543	20872335	23722345
2	1753267	0	0	0	920046	2673313	2897285
3	0	0	0	0	-1532	-1532	19152
4	0	0	0	11790	448917	460707	941071
5	19751759	0	0	166076	-19977159	-59324	3066379
6	5347774	0	1235028	21615	-10743064	-4138647	5246848
7	1329913	0	0	0	-2203015	-873102	462581
8	238703	0	0	0	-316140	-77437	43763
9	75468	0	5809729	0	2350672	8235869	9685851
10	4708613	0	229882	0	-3966606	971889	3048735
11	19915057	6704644	536392	0	-4078971	23077122	28667465
TII	55510875	6704644	9794551	377432	-21246309	51141193	
CE							
GOS	0	0	0	0	0	0	
HOA							
NHOA	0	0	0	0	0	0	
TPI	0	0	0	0	0	0	
TI	55510875	6704644	9794551	377432	-21246309	51141193	

Table B3b. 12 Sector Transaction Table (Regio 1 - Ilocos Region 1994, in thousand pesos)

Code	PCE	GCE	GFCF	CS	E - M	TFD	TO
1	2390321	0	1983520	177951	16320543	20872335	23722345
2	1753267	0	0	0	920046	2673313	2897285
3	0	0	0	0	-1532	-1532	19152
4	0	0	0	11790	448917	460707	941071
5	19751759	0	0	166076	-19977159	-59324	3066379
6	5347774	0	1235028	21615	-10743064	-4138647	5246848
7	1329913	0	0	0	-2203015	-873102	462581
8	238703	0	0	0	-316140	-77437	43763
9	75468	0	5809729	0	2350672	8235869	9685851
10	4708613	0	229882	0	-3966606	971889	3048735
11	19915057	6704644	536392	0	-4078971	23077122	28667465
12	0	0	0	0	0	0	25862917
TII	55510875	6704644	9794551	377432	-21246309	51141193	103664392
GOS	0	0	0	0	0	0	25278276
NHOA	0	0	0	0	0	0	25278276
TPI	0	0	0	0	0	0	25278276
TI	55510875	6704644	9794551	377432	-21246309	51141193	

Table B4a is the technical coefficient matrix, represented by the matrix ‘A’ in equation 3. To derive this matrix, each of the z_{ij} elements of Table B2a are divided by the appropriate column sum X_j, as shown in equation 3a. The column sums X_j are represented in Table B2a by the Total Input (TI) row. It should be noted that the column sum X_j is the sum of all inputs; those of both the production and payments sectors.

The technical coefficient a_{ij} may be interpreted as the (currency unit)’s worth of sector i input per (currency unit)’s worth of output of sector j. The technical coefficients are viewed as representing a fixed relationship between a sector’s outputs and its inputs. If technology changes, then the values for the technical coefficients will change.

An alternative definition of the technical coefficient is that it indicates the portion of a column sector j’s input demand that is provided for by row sector i. Thus, sector 1 (agriculture) provides 10% of its own input demand.

The vector and matrix requirements of equation 3 are now provided for. To gain the form of equation 3, the Leontief inverse matrix $(I – A)^{-1}$ is created (Table B5a).

Appendix B

Table B4a. **11 Sector Technical Coefficient Matrix (Region 1 - Ilocos Region, 1994).**

Code	1	2	3	4	5	6	7	8	9	10	11
1	0.101159	0.000069	0.001044	0.000000	0.104894	0.005608	0.000000	0.000000	0.000000	0.000000	0.001726
2	0.000015	0.051730	0.000000	0.000002	0.007940	0.000011	0.000000	0.000000	0.000000	0.000000	0.000860
3	0.000000	0.000000	0.010338	0.003649	0.003755	0.000697	0.001250	0.000046	0.000134	0.000000	0.000000
4	0.000018	0.000009	0.000000	0.000000	0.000097	0.047809	0.003716	0.000000	0.023275	0.000006	0.000028
5	0.042670	0.061574	0.000783	0.019307	0.189443	0.047837	0.001613	0.005987	0.036927	0.002117	0.012555
6	0.067037	0.087216	0.102548	0.201255	0.100285	0.319247	0.287320	0.120856	0.348257	0.239690	0.019648
7	0.005966	0.009254	0.002454	0.005207	0.026680	0.057920	0.022653	0.108425	0.010508	0.012549	0.010838
8	0.000184	0.000000	0.000000	0.000046	0.003833	0.000034	0.000000	0.000000	0.001175	0.002467	0.001499
9	0.000271	0.003911	0.001253	0.013229	0.008103	0.012299	0.010351	0.036081	0.031935	0.019375	0.016667
10	0.014932	0.019917	0.053676	0.013641	0.028320	0.025334	0.000000	0.010922	0.061219	0.019999	0.013550
11	0.031361	0.021517	0.035349	0.052083	0.098678	0.075793	0.088062	0.066997	0.102812	0.147414	0.044391

Table B4b. **12 Sector Technical Coefficient Table (Region 1 - Ilocos Region 1994, in thousand pesos)**

Code	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12
1	Agriculture	0.101159	0.000069	0.001044	0.000000	0.104894	0.005608	0.000000	0.000000	0.000000	0.000000	0.001726	0.043060
2	Fishery	0.000015	0.051730	0.000000	0.000002	0.007940	0.000011	0.000000	0.000000	0.000000	0.000000	0.000860	0.031584
3	Forestry	0.000000	0.000000	0.010338	0.003649	0.003755	0.000697	0.001250	0.000046	0.000134	0.000000	0.000000	0.000000
4	Mining and quarrying	0.000018	0.000009	0.000000	0.000000	0.000097	0.047809	0.003716	0.000000	0.023275	0.000006	0.000028	0.000000
5	Manufacturing I	0.042670	0.061574	0.000783	0.019307	0.189443	0.047837	0.001613	0.005987	0.036927	0.002117	0.012555	0.355818
6	Manufacturing II	0.067037	0.087216	0.102548	0.201255	0.100285	0.319247	0.287320	0.120856	0.348257	0.239690	0.019648	0.096337
7	Electricity, gas and water	0.005966	0.009254	0.002454	0.005207	0.026680	0.057920	0.022653	0.108425	0.010508	0.012549	0.010838	0.023958
8	Waterworks and supply	0.000184	0.000000	0.000000	0.000046	0.003833	0.000034	0.000000	0.000000	0.001175	0.002467	0.001499	0.004300
9	Construction	0.000271	0.003911	0.001253	0.013229	0.008103	0.012299	0.010351	0.036081	0.031935	0.019375	0.016667	0.001360
10	Transpo., comm. and storage	0.014932	0.019917	0.053676	0.013641	0.028320	0.025334	0.000000	0.010922	0.061219	0.019999	0.013550	0.084823
11	Other Services	0.031361	0.021517	0.035349	0.052083	0.098678	0.075793	0.088062	0.066997	0.102812	0.147414	0.044391	0.358760
12	Household sector	0.391233	0.347343	0.791719	0.258193	0.151311	0.090028	0.180641	0.282567	0.134677	0.291733	0.210888	0.000000

Table B5a. 11 x 11 Leontief Inverse Matrix (Total Output Multiplier)

Code	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11
1	Agriculture	1.121608	0.012182	0.004162	0.007904	0.149256	0.021981	0.007342	0.005284	0.014830	0.006836	0.004898
2	Fishery	0.000653	1.055385	0.000182	0.000494	0.010729	0.001009	0.000429	0.000348	0.000940	0.000467	0.001142
3	Forestry	0.000413	0.000546	1.010691	0.004213	0.005095	0.001914	0.001906	0.000575	0.001197	0.000553	0.000159
4	Mining and quarrying	0.007055	0.008956	0.009374	1.017096	0.013339	0.076906	0.027394	0.014770	0.054623	0.020823	0.003389
5	Manufacturing I	0.068988	0.093112	0.014265	0.047644	1.262035	0.100809	0.034797	0.028560	0.090313	0.032897	0.021345
6	Manufacturing II	0.143308	0.180460	0.191563	0.344837	0.262828	1.587392	0.480639	0.276711	0.627618	0.416990	0.059267
7	Electricity, gas and water	0.018380	0.024532	0.016000	0.028933	0.054464	0.100187	1.054924	0.130362	0.054843	0.042033	0.016553
8	Waterworks and supply	0.000633	0.000537	0.000323	0.000481	0.005278	0.000844	0.000438	1.000407	0.002113	0.003046	0.001743
9	Construction	0.004575	0.009330	0.006566	0.021242	0.018920	0.026940	0.020930	0.045125	1.048246	0.030721	0.019846
10	Transportation, communication and storage	0.024068	0.030516	0.062252	0.027488	0.049845	0.049399	0.017364	0.023884	0.088096	1.037362	0.018222
11	Other Services	0.061656	0.056609	0.066511	0.097357	0.172335	0.161129	0.145705	0.116594	0.194205	0.205278	1.060329
TOM	Total Output Multiplier	1.465	1.485	1.397	1.620	2.042	2.164	1.824	1.669	2.220	1.440	

Table B5b. 12 x 12 Leontief Inverse Matrix (Total Output Multiplier)

Code	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12
1	Agriculture	1.197679	0.079294	0.138001	0.061491	0.203582	0.062275	0.052399	0.064370	0.063039	0.070612	0.043342	0.155672
2	Fishery	0.027619	1.079175	0.047625	0.019489	0.029987	0.015293	0.016401	0.021293	0.018029	0.023074	0.014769	0.055182
3	Forestry	0.001974	0.001923	1.013439	0.005313	0.006210	0.002741	0.002831	0.001788	0.002187	0.001862	0.000948	0.003196
4	Mining and quarrying	0.018857	0.019369	0.030140	1.025410	0.021768	0.083158	0.034385	0.023938	0.062102	0.030718	0.009353	0.024153
5	Manufacturing I	0.409252	0.393299	0.612923	0.287339	1.505037	0.281044	0.236337	0.292850	0.305950	0.318165	0.193308	0.696315
6	Manufacturing II	0.378036	0.387541	0.604542	0.510188	0.430460	1.711726	0.619669	0.459028	0.776373	0.613780	0.177894	0.480346
7	Elect., gas and water	0.065546	0.066143	0.098984	0.062159	0.088148	0.125171	1.082861	0.166997	0.084734	0.081576	0.040390	0.096521
8	Waterworks and supply	0.005779	0.005077	0.009378	0.004106	0.008953	0.003570	0.003487	1.004405	0.005375	0.007360	0.004344	0.010531
9	Construction	0.020056	0.022988	0.033802	0.032147	0.029976	0.035140	0.030099	0.057150	1.058057	0.043700	0.027670	0.031680
10	Transpo., comm.& storage	0.109571	0.105949	0.212686	0.087720	0.110908	0.094690	0.068007	0.090296	0.142282	1.109046	0.061434	0.174973
11	Other Services	0.407030	0.361304	0.674161	0.340652	0.418986	0.344071	0.350271	0.384853	0.413080	0.494831	1.234874	0.706772
12	Household sector	0.714532	0.630372	1.257144	0.503344	0.510287	0.378482	0.423220	0.554991	0.452823	0.599046	0.361110	1.462215
TOM	Total Output Multiplier	3.356	3.152	4.733	2.940	3.364	3.137	2.920	3.122	3.384	3.394	2.170	3.898

The elements of the Leontief inverse are known as sectoral multipliers. Each element indicates the value of the change of a row sector's output due to a unit change in final demand for the column sector's output. This may be seen by rearranging equation 4a to give

8) $dX / dY = (I - A)^{-1}$

The column sums of the Leontief inverse (that is, the column sums of the sectoral multipliers) are known as simple output multipliers (in the case of an exogenous household sector) or total output multipliers (in the case of endogenized households). The output multiplier for a sector is the total change in production for all sectors needed to service a one unit (say, one peso) change in final demand for that sector. The simple output multiplier captures the direct and indirect impacts of a unit change in final demand of a sector. The direct impact is the unit change in production that satisfies the unit change in final demand. The indirect impact represents the additional production needed to satisfy the resulting changes in intermediate demands. In the case of an endogenized household sector, an induced impact is added to the simple multiplier impacts to provide the total output multiplier. The induced impact represents the additional consumer expenditures generated from the changes in income due to labor payments for the changes in production.

A low column sum (output multiplier) reveals a weak sectoral inter-linkage; otherwise, it shows a sector's strong dependence on the other sectors' output to meet a unit increase in final demand for its output. The sector with the largest multiplier provides the largest total impact on the economy. The simple and total output multipliers are provided on the bottom rows of Tables B5a and B5b, respectively.

The basic components of the IO model are now provided for. The next step in modeling residual generation with the IO model is to create the residual coefficient matrix 'C' of equation 1. This first required the quantification of residual generation in the study site, and then applying the information to equation 3a. The estimation of residual generation is described in Annex B. The residual coefficient matrices for the various models are given in Tables B6a-b.

Table B6a. 11 x 11 Residual Coefficient Matrix

Description	1	2	3	4	5	6	7	8	9	10	11
N	0.000413	0.000021	0	0	0.000023	0	0	0	0	0	0.000012
P	0.000234	0.000019	0	0	0.000000	0	0	0	0	0	0.000005
SS	0.1157700	0.000023	0	0	0.000208	0	0	0	0	0	0.0023111
C	0.000000	0.000003	0	0	0.000223	0	0	0	0	0	0

Table B6b. 12 x 12 Residual Coefficient Matrix

Description	1	2	3	4	5	6	7	8	9	10	11	12
N	0.000413	0.000021	0	0	0.000023	0	0	0	0	0	0.000012	0.000088
P	0.000234	0.000019	0	0	0	0	0	0	0	0	0.000005	0.0001145
SS	0.115770	0.000023	0	0.022030	0.000208	0	0	0	0	0	0.002311	0
C	0	0.000003	0	0	0.000223	0	0	0	0	0	0	0.0010139

Analogous to the concept of the output multiplier is that of the residual multiplier. The residual multiplier matrix M is given as:

$$M = C\,(I-A)^{-1}.$$

The elements of $M = [m_{kj}]$ show the amount of residual k generated for a one unit change in final demand in sector j. These residual multipliers for the 12 sector model are provided in Table B7. As an example, in order to service a one unit (in the tables presented, one unit is one thousand pesos (1994), equivalent to about $40 U. S.) increase in agricultural final demand, approximately 0.00057 metric tons (or 0.57 kg) of nitrogen will be discharged into coastal waters.

Table B7. Residual Multiplier for 12 Sector I/O Model

Description	1	2	3	4	5	6
N	0.000573	0.000125	0.000192	0.000081	0.000170	0.000070
P	0.000365	0.000113	0.000181	0.000074	0.000109	0.000060
SS	0.140097	0.010548	0.018327	0.030556	0.025330	0.009896
C	0.000816	0.000730	0.001411	0.000574	0.000853	0.000446
	7	**8**	**9**	**10**	**11**	**12**
N	0.000069	0.000088	0.000079	0.000096	0.000070	0.000220
P	0.000063	0.000081	0.000069	0.000088	0.000058	0.000209
SS	0.007683	0.008930	0.009685	0.010062	0.008118	0.020334
C	0.000482	0.000628	0.000527	0.000678	0.000409	0.001638

The residual coefficient matrix is created from a pre-existing estimate of residual generation. This is then allocated among the sectors of the IO model. Thus the estimates of residual generation for the **given** levels of economic activity represented by the IO model are as good as (in fact the same) the estimates provided by the RA exercise. It is hoped that, despite the high level of aggregation in the IO models, estimates of **changes** in residual flows brought about by changes in economic activity will be better than estimates given by a RA model.

While the estimates of residual generation from the rapid assessment exercise are at best 'guesstimates', the quality of the estimates may be ascertained to some degree by comparing the obtained values to the results from the biogeochemical modelling. The results shown in Table B8 indicate the ambient concentrations of N, P, C, and SS in the water column, and the percentage of the ambient concentration that may be attributed to economic activity. The numbers do not seem to be too unreasonable.

Table B8. Estimation of total material concentrations in Lingayen Gulf and those contributed by economic activities.

Material	Ambient concentration	Concentration derived from economic activities (% contribution)[3]
DIN	0.81[1] μmol/L	0.33 mol/L (41)
DIP	0.12[1] μmol/L	0.04 mol/L (33)
TSS	2.5± 4.5 mg/L 6.3 mg/L[2]	2.6 mg/L (37-100)

1 San Diego-McGlone, et. al., 1998
2 Siringan, et. al., 1998
3 McGlone & Caringal, 1998

With the completion of the residual coefficient matrix, we have the model of equations 5–7, and are now prepared to perform some scenario analyses.

Scenario Analysis

Scenario analysis may take the form of projecting changes in either final demand (ΔY in equation 6) or in total output (ΔX in equation 7). The result for either approach will be an estimate of the overall change in residual generation brought about by a change in economic activity. Two scenarios are presented for the purpose of demonstrating the workings of the model, and to make comparison with results from a simpler rapid assessment approach.

12-Sector Model

The following scenarios are presented for the 12-sector model (see Table B9):

i) 53% growth in the net export of agriculture, translating into a 20% growth in final demand for agriculture. This scenario reflects potential expansion in the agricultural sector due to improved irrigation facilities and infrastructure, and a policy shift toward export-oriented activity, coupled with an emphasis on food security.

ii) 20% across- the- board growth in total final demands.

Table B9. Changes in the total final demand (DY) 12 Sector Regional Model, 1994 (in thousand pesos)

Code	Description	Scenarios	
		1	2
1	Agriculture	3696402.80	3696402.80
2	Fishery	0.00	184009.20
3	Forestry	0.00	306.40
4	Mining and quarrying	0.00	92141.40
5	Manufacturing I	0.00	3962216.60
6	Manufacturing II	0.00	1897284.20
7	Electricity, gas and water	0.00	440603.00
8	Waterworks and supply	0.00	63228.00
9	Construction	0.00	1632080.20
10	Transportation, communication and storage	0.00	747344.80
11	Other services	0.00	632413.00
12	Household	0.00	0.00

Results

The change in Final Demand vectors for each scenario are given in Table B9. The resulting changes in Total Output are provided in Table B10. The changes in residual generation are shown in Table B11, along with the changes predicted by the RA methodology.

Table B10. Induced changes in total output (Dx) (in thousand pesos)

Code	Initial X	Scenarios			
		1		2	
		ΔX	%	ΔX	%
1	23722345	4427104.603		5582417.598	
2	2897285	102089.450		514890.217	
3	19152	7297.831		45178.466	
4	941071	69704.380		558673.958	
5	3066379	1512760.299		9090308.156	
6	5246848	1397374.316		8609449.000	
7	462581	242285.253		1559430.644	
8	43763	21363.099		146986.036	
9	9685851	74134.871		2060646.255	
10	3048735	405017.947		2187334.982	
11	28667465	1504548.147		5919144.825	
12	25862917	2641199.414		7180584.346	

In the first scenario, a 53% growth in the net export of agriculture translates into a 20% growth in final demand for agriculture. Final demand for all other sectors is held constant. Table B10 shows that Total Output changes in all sectors, with percent changes ranging from 1.5% to 23.8%. This is a clear indication of the interrelationships present in the economy. Table B11 shows the resulting changes in residual generation. Nitrogen increases by 2117 mt, (13.9%), phosphorus by 1349 mt (11.1%), suspended solids by 517856 mt (18.3%), and carbon by 3015 mt (5.3%). The rapid assessment model would estimate lower increases in each residual (the increase in agricultural output necessary to meet the increased final demand, multiplied by the residual coefficients for agriculture). As shown in Table B11, the RA model would predict a 10 % increase in N, a 7.1% increase in P, a 15.1% increase in SS, and no change in C. Thus, the rapid assessment model would seem to underestimate residual generation by 28 % for N, 36 % for P, 17.4% for SS, and would completely ignore any changes in C.

Table B11. Induced changes in residual generation, DR (in metric tons)

		IO Model			
#	Initial R	Scenario 1		Scenario 2	
		ΔR	%	ΔR	%
N	15189	2116.829	13.90	3236.472	21.30
P	12117	1349.224	11.10	2170.397	17.90
SS	2833967	517855.724	18.30	674166.894	23.80
C	56975	3015.140	4.75	9306.558	16.30
		Rapid Assessment Method			
#	Initial R	Scenario 1		Scenario 2	
		ΔR	%	ΔR	%
N	15189	1525	10.0	1630	10.7
P	12117	866	7.1	873	7.2
SS	2833967	427933	15.1	432253	15.3
C	56975	0	0.0	883	1.5

In the second scenario again shows how the rapid assessment model may underestimate residual generation. The RA method would essentially estimate a change in residuals equal to the change in sectoral output (set equal to the change in final demand) multiplied by the sectors share in residual generation. For example, the 20% increase in final demand for agriculture would be equivalent to a 15.6% increase in agricultural output. This would be multiplied by the 64.4% share that agriculture has in the generation of nitrogen, to give an estimated 10% increase in nitrogen generation. As seen in Table B11, for the second scenario the RA method would underestimate nitrogen generation by 49%, phosphorus by 60 %, suspended solids by 36%, and carbon by 90%.

The above scenarios serve to demonstrate how the rapid assessment methodology represented by Equations 1 and 2 may result in a significant underestimation of residual generation. The input-output model, by capturing intersectoral linkages, provides a more thorough assessment of the changes in activities that lead to residual generation. It should be noted that the economy of the study site is dominated by agriculture, with relatively little industrial development. In an economy with a more robust industrial sector, particularly in the agricultural product-based Manufacturing 1 sector, the inter-linkages among residual-generating sectors would be stronger, and the relative value of the input-output model would be that much greater.

One potential weakness of the specific IO model presented above deserves some discussion. Due to time and data constraints, the regional IO model as presented is of the competitive type. That is, no distinction is made in the transactions table between commodities produced within the region and those imported from other regions, whether domestic or international in origin. This provides no great obstacle in using the IO model for estimating residual generation. For this purpose, one must simply assume that during conditions of changing demand, the mix of regionally and non-regionally sourced inputs does not change. This assumption is an extension of the typical IO assumption that the technological input mix is constant (that is, the coefficients of the A matrix are constant). Of course, over longer time horizons, these assumptions become less tenable, and this is a common criticism of the use of IO tables. Typically, however, governments attempt to overcome this criticism by updating their IO tables every 5 or 10 years.

Use of the competitive type IO model becomes more problematic when using it for simple or total output multiplier analysis. In such cases, it becomes more important to make the distinction between inputs produced within the regional economy and those imported from outside. Analyses making use of output multipliers, however, is not of primary interest in terms of meeting the objectives of LOICZ. While analyzing the changes in multipliers and in the technological coefficient matrix over time could theoretically be of use, the practical fact is that the methods of constructing IO tables have changed over time, and typically, IO tables over time are not compatible for comparison. For example, the period between 1979 and 1985 saw the introduction of the distinction between commodities and industries, thus allowing an improved method of allocating secondary output of industries. The negative result of this is that pre- and post-1979 IO tables are no longer directly comparable.

Should the use of IO models prove to be of benefit to LOICZ, a primary concern for future studies should be an agreement on the particular type of IO model to be used, so that cross-country or cross-regional comparisons may be made. It seems likely that the non-competitive type model may be of more use, particularly in regard to making cross-country comparisions of forward and backward linkages between sectors. The choice between survey –based regional models and, for example, simple location quotient reduction methods of regionalization is also a question that should be addressed. The ultimate choice of model type should reflect the LOICZ objective of creating models in a wide variety of sites, and the need for cross country comparison and scaling activities.

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