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An analysis of historical national reports of inland capture fishery statistics in the Asia-Pacific region (1950-2007)

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by

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FOREWORD

The purpose of this paper is to analyse whether the apparent trend in inland capture fishery production in the Asia-Pacific region since 1950 according to FAO statistics is reflective of the growth in inland fisheries or whether it is influenced by changes in statistical reporting practices.

The objective of this analysis was to identify large changes (between years) that are significant for a reporting country and to investigate whether these changes also affect the regional change of that year (for the countries of the Asia-Pacific region). An analysis was undertaken, albeit making several unsubstantiated assumptions, which provided indications that reporting practices have indeed changed and that historical catches were probably higher.

The review suggests that the regional trend of continually increasing production may be misleading and hides a period of limited growth in production. The effect of the trend line when compared against growth in populations of the countries reviewed indicates that per capita fish availability rose up to a peak in 1975, but subsequently declined until the early 1990's. This has more recently started to increase again, possibly due to a number of factors particularly stock enhancement programmes.

The results presented in this study have implications for policy and our understanding of the status of inland fisheries in the region, as the review concludes that even where figures are adjusted upwards, these may still not be indicating increasing fishery production in some countries, but rather, the readjustments are reflecting previous systematic under-estimates and that it is possible that some inland fisheries may still have a declining trend.

He Changchui
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INLAND FISHERY PRODUCTION SEEMS TO BE INCREASING, BUT THIS HIDES AN UNDERLYING PROBLEM

Inland capture fisheries in the Asia-Pacific region are undoubtedly some of the most important fisheries of the world and are feeding and employing millions of people in rural and riparian areas throughout Eastern, South-Eastern and South Asia. The massive, dispersed nature of many inland fisheries activities has challenged systems of information and data collection ever since man has tried to account for these fisheries as early as the 1700s (Dmitry 2007).

For the purposes of this review, inland fisheries will be considered as per the FAO definition for statistical purposes. This is to ensure consistency with the FAO capture fishery dataset, which separates capture fishery statistics into the various sources of the production. For inland fisheries, this source of production is termed “Inland waters”. At national level there may be some differences between countries in terms of how inland fisheries are defined. This is because some countries include the fishery production of coastal brackish water lagoons and even estuaries as “inland waters”.

In other cases, culture-based fisheries (i.e. fisheries where the stocked fish are produced from aquaculture hatcheries) may be recorded varyingly as either as capture fisheries production or aquaculture production. Culture-based fisheries that are truly considered aquaculture operations can also be considered to have some sort of ownership applied to the stock released and this infers that the stock is placed into a water body where some sort of control can be exercised. Production from systems such as this should be recorded as aquaculture production. This is quite different from the release of fish into open waters or into floodplains, where there is less control over recapture and the production ought to be recorded as that of capture fisheries.

The release of stock into open waters and floodplains, where significant natural mortality can be expected and the stock introduced may also breed is termed “fishery enhancement”. “Enhanced fisheries” is considered wild capture fishery production, not aquaculture production and is recorded as such. As will be seen later in this review, the mixing between culture-based fisheries, enhanced fisheries and true inland (wild) capture fisheries may be distorting production trends at national and even regional level.

The global inland capture fisheries catch passed 10 000 000 tonnes for the first time in 2007 with developing countries accounting for more than 94 percent of the total global inland catches in 2004 (FAO 2007), and almost 91 percent in 2006. China is the biggest producer followed by Bangladesh and India, with their combined production accounting for more than 40 percent of the total reported global production.

Since 1950, FAO has requested its member countries to report inland fisheries capture statistics as part of their fisheries reporting to the Organization, to enable the tracking of trends in global inland fisheries production. From these reported data, there is an apparent increasing trend in the production from global and regional inland fisheries during the period 1950-2007 (Figure 1) and this increase in the global trend is regularly reported in global analyses (FAO 2002, FAO 2004, FAO 2009b). FAO Member States committed themselves to improving such statistics by adopting in 2003 the Strategy for Improving Information on the Status and Trends of Capture Fisheries and this strategy was subsequently endorsed by the UNGA.

Whilst the overall regional trend of inland fishery production appears show sustained increase in production, it is not clear when viewing aggregated statistics whether this is due to the aggregated, gradual increase in production from all countries’ inland fisheries, or due to large, occasional increases from individual countries.

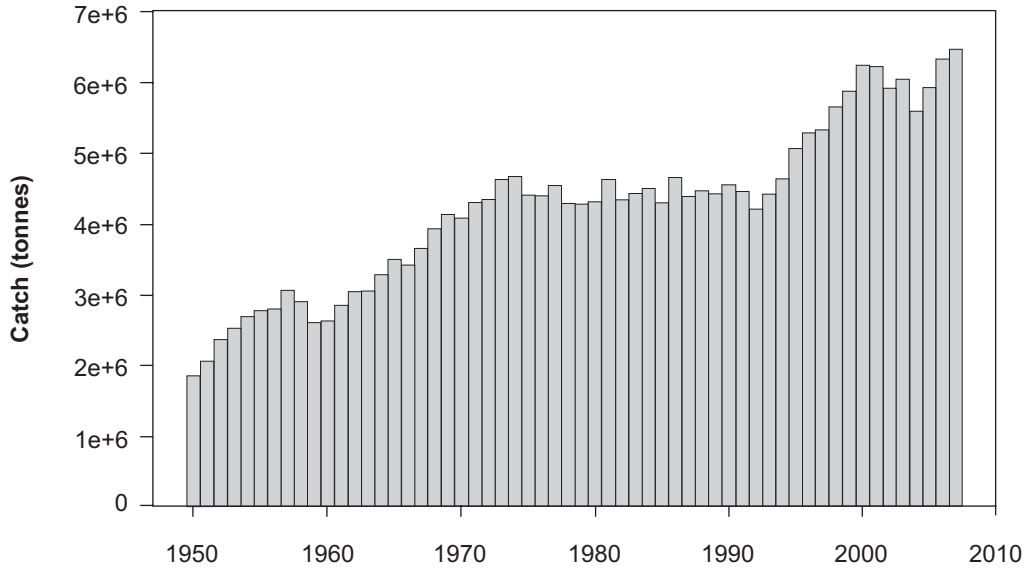

Figure 1 The total inland capture fisheries production from APFIC region between 1950 and 2007.

Based on this significant and continuous trend, several predictions have been made as to where global inland fisheries are developing, with an apparent general consensus that there still seems to be further potential for growth in the sector. That is, the apparent increase in global inland fisheries production appears to indicate that the global threshold of production has not yet been reached.

At first sight, this trend of increasing production may encourage an immediate conclusion that all is well in the fisheries of the region and that the fisheries have not yet been fished to their fullest extent. This assumption has already been shown to be based on flawed understanding of the nature of production from inland fisheries. It is becoming more or less accepted that inland fisheries can continue increasing their yield, or sustain yields in the face of mounting fishing pressure. This occurs as a result of the trend to fish down the fish assemblage and the driving of a fishery towards smaller faster recruiting species that feed at lower trophic levels. This is accompanied by a decline in larger, longer lived species (which tend to mature later or which are more carnivorous) and as a result, species diversity in such systems also tends to decline (Figure 2).

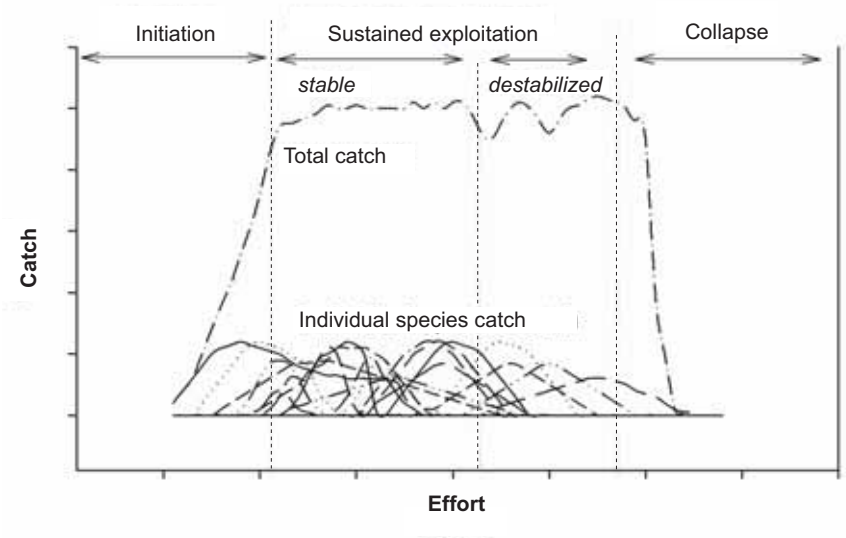

Figure 2 Diagram of fishing down the food chain effects on catch in freshwater. Figure adapted from figures 7.15 and 7.16 in Welcomme (1985)

The processes involved in the fishing-down process lead to a number of indicators, such as length of catch and species composition of the catch. A trend in catch composition towards smaller species that feed at low trophic levels and which mature at a relatively early age is a classic case of overfishing and fishery decline (the root causes may be various, but indicate the quality of the fishery is changing) and thus these indicators can be used to assess the status of the fishery (Welcomme 1999).

The levelling off of catches in Southeast Asian inland fishery production has already been reported and production has been stable in recent years if consideration is given to the improved quality of inland fisheries data in the region (Lymer 2008a).

INLAND FISHERIES PROVIDE FOOD AND INCOME – BUT ARE OFTEN OVERLOOKED OR UNDERVALUED

Inland fisheries are generally rather labour intensive and in most cases do not lend themselves to mechanisation and industrialisation. They are thus typically driven by individual human effort and the overall number of people in the fishery. A feature of this is that they are typically not great wealth creators for individual fishers, but may in their aggregate sense, be massive suppliers of food and artisanal income. As such, inland fisheries can be considered significant contributors to rural food security and income generation, providing a diverse set of livelihoods benefits to some of the poorest households in the rural sector. They do not, however, usually provide an opportunity for taxation and levies and thus awareness of their socio-economic importance is often dissipated in government development programmes.

It has been frequently reported by those working closely with inland fisheries that catches are in fact declining. It can be argued that this has been a complaint of fishers since humanity began fishing, but there is at least some documented evidence (often from participatory surveys and assessments of inland fishing communities) to show that more recently this has been the case. The review of Baran & Myschowoda (2008) is a good example for Southeast Asia. The important consideration here is that the individual catch of fishers may well be declining, but that the aggregate catch can still increase, because overall the total number of fishers may be increasing. Therefore an increase in total capture production is not a contradiction to decreasing individual catches.

Beyond a certain point, declining catches can deter fishing activity and fishers will be forced to seek alternative employment. However, one of the features of the inland fisheries of the region is that they are pursued as a part time activity and occasional or opportunistic activity according to seasons. This means that absolute dependence on the fishery is confined to full-time fishing families, and that the decision to fish or not is rarely based on absolute economic necessity and is only one of a number of options. Thus, declining yields, whilst disappointing to a fisher, may not cause the person to cease the activity as quickly as would occur where this is a primary source of food and income.

Exceptions to this generalisation are the large concession-based inland fisheries systems in the region, where fishing access is restricted and huge areas are leased to operators to exploit as fishing companies (e.g. Fishing Inns in Myanmar, the Fishing Lots in Cambodia, and large cooperative-managed culture-based or enhanced fisheries that are found in some large water bodies[1]). Since most inland fisheries are not exploited industrially (or mechanically), it is possible to make a general assumption that total fishing effort of inland fisheries is a direct reflection of the individual human effort being applied[2]. It should also be recognized that inland fisheries are sensitive to biological changes

[1] Note that if the fisheries are culture-based fisheries, then this production should be recorded as aquaculture production rather than inland fisheries production, whereas enhanced fisheries are properly recorded as capture production.

[2] However, because the time any individual may devote to fishing in any one year is extremely variable this is a very unreliable measure of effort.

and a significant driver of this is biological productivity (increasing with nutrient runoff or decreasing dues to river damming/flood plain reduction etc.). Connectivity of systems (i.e. dams and weirs, or connectivity across flood plains) will also influence production of some species. Biological and habitat factors are likely to be factors fisheries production declines, and will also affect species composition. It is less likely that this would be a factor in fishery production increase, which is more likely to be driven by fishing effort.

To summarize:

- The apparent regional trend of inland fishery production in the Asia-Pacific region is one of sustained increase in production.
- It is not clear, when viewing aggregated statistics, whether this is due to a gradual increasing production from all countries inland fisheries, or due to large increases from individual countries.
- Reports from individual fishers of declining catch may not contradict the recording of overall increasing yield from a fishery
- Increasing fishing pressure tends to drive the fishery towards small faster recruiting species and species diversity may decline (an indicator of this pressure) as a result.
- Inland fishing activity is typically dispersed and production is related to the number of fisheries engaged full time or occasionally in the activity. The number of fishers is probably a reflection of a proportion of the overall population of a country or within a particular fishing region/ area.
- It is not clear whether the rising total is due to better reporting of catches that are already being made by previously unrecorded sectors of the fishery, such as rice field fisheries or small scale subsistence catches, or represent real gains in production. If the latter, stock enhancement may have played a part.

THE STATISTICS IN DETAIL

Trend-lines based on aggregated country data provide a rapid, easily visualised view of a particular issue and enable rapid communication of a single message. However, the risk of this is that over-aggregation of data may hide significant underlying variations in individual countries and rapid assumptions based on the overall trend hide important, and sometimes surprising, trends at the national level.

FAO has highlighted its concerns regarding the quality of inland fisheries data, as reported to FAO, in recent years (FAO 2002b, FAO 2004, FAO 2007, FAO 2009) and this has also been noted far earlier (Gulland 1970). The quality of the data reported to FAO from countries and also the estimates that FAO has to make when no data have been reported[3] means that the global and regional aggregate inland fisheries statistics are indicative rather than absolute.

It is now widely acknowledged that there are many instances of unreported (or under-reported) catch in inland fisheries, mainly because of the diffuse and small scale nature of individual fisheries where landings are not recorded as much of the catch goes directly into domestic consumption (Welcomme 1976, Coates 2002). The review of Coates (2002) noted that national inland fisheries statistics for a number of countries in the Asia-Pacific region did not show the variations typically expected for

[3] For several countries data extracted from FishStat plus, the data are not official submissions by the country but are FAO estimates in absence of submission.

inland fisheries as a result of variations in the annual monsoon rains, seasonal effects and dry versus wet years, all of which are known to affect fisheries productivity due to year-on-year variations in the area inundated which influence primary productivity, migration and breeding and recruitment success. They also influence the ease with which fish are captured. In well monitored fisheries these significant annual variations in catch as a result of seasonal and climatic factors are clearly observed. National fisheries statistics reported to FAO, tend not to show these variations, indicating that they are smoothed annual data, partially as a result of within-country aggregation, and also because they are based on estimates, which themselves are often based on proxy indicators of the fishery. In some cases, fisheries catches and landings are recorded for some indicative fisheries and these are subsequently extrapolated up to a national figure.

It is not the purpose of this review to detail the issues of the collection of statistics, as this has been dealt with in greater detail in Coates 2002 and elsewhere (FAO 2001, FAO 2002a), but rather to draw attention to the effect of large revisions of annual estimates by individual countries on the regional trendline. It is sufficient to note that as a result of the tendency to use proxy indicators and estimates; inland fisheries statistics for an individual country will tend to drift away from actual production or may be quite erroneous from the start.

Most countries at some stage review their inland fisheries statistics basing this on newer information, or improved estimation of the proxy indicators. Typical proxy indicators include: five-yearly or decadal fisheries census; number of fishers; CPUE studies for key fisheries; biological yield estimates; and household consumption or economic survey/census data. As a result of this type of updated information, countries may revise their inland fisheries production quite radically, resulting in a significant increase or decrease in the reported inland fishery production of the country. This is not a variation one would expect to see as a result of climatic driven variations in the fishery, but a significant increase or decrease in inland fisheries production. Such variations have occurred since 1950 in individual country annual reports of inland fishery production, but the impact of these significant country changes is rarely seen as a major change in the aggregated statistics for the region.

Large changes in national estimates indicate that there may have been a significant revision in the statistical data collection system, or an adjustment in the national estimate based on new supporting evidence. The different types of changes at the country level which can induce this sort of large shift include:

- The availability of direct measurement data, rather than estimates or proxies;
- Revision of the area of fisheries such as inclusion of other habitats[4] (where estimates are based on habitats and productivity per unit area estimations (new information of fishery habitats, wetlands areas previously not included);
- Inclusion of previously unrecorded fisheries (e.g. inclusion of artisanal or subsistence fisheries, where previously only large scale fisheries were reported)[5];
- Revision of the number of fishers (typically as a result of census updates);
- Recalculation of fixed transformation values (e.g. catch/ha or catch/fisher)[6];

[4] In the world there are 304 million natural lakes that cover 4.2 million km^2 (Downing & Duarte 2009). In addition, the land area covered by constructed lakes and impoundments is 335 000 km^2 (77 million impoundments) and of this area 76 830 km^2 are farm ponds.

[5] The upward revision of Cambodia's inland fisheries production was based on the inclusion of floodplain fisheries. Previous production was only reported from concessional fisheries.

[6] China PR uses factors to estimate production from a variety of systems and these factors may be modified.

- Availability of updated consumption data, economic survey data (e.g. per capita consumption of freshwater fish[7]); and
- Revision based on assumptions regarding effects of enhancements of wild stocks due to stocking or other interventions[8].
- Changing policy priorities may encourage revision of production estimates upwards or downwards. These estimates can be aggregated into national figures and subsequently emerge, quite distorted from actual production levels.

Table 1 The distribution of annual percentage change in inland fisheries production for Asia-Pacific countries 1950-2007

Percentage change between successive years	Number of records
+280	5
+260	0
+240	1
+220	0
+200	0
+180	1
+160	1
+140	1
+120	3
+100	9
+80	8
+60	22
+40	31
+20	91
0	669
-20	335
-40	72
-60	10
-80	5
-100	3
-120	0

In the event of a significant revision of the national production in the space of a single year's reporting and assuming that the error that is being corrected was due to an incremental underestimation over a number of years, what would be the effect of smoothing this large increase backwards? The question is whether these revisions of yield alter the shape of the regional trend line, if the revisions are "back-calculated"[9] across the previous reported data of a country. It is important to know if the continually increasing trend in inland fisheries is based on a maintained small increase in all countries or a result of occasional large (of a size that significantly affects the aggregated regional production figure) increases of individual countries. Large individual increases in the reported data (in this paper a "large" increase is taken as a larger than 40% increase from previous years' production for any country) would indicate that something else but natural variability in the data. Out of a total of 1 267 records, 82 records exceeded 40 percent increase and 90 records decreased more than 40 percent between successive years (Table 1). The total number of records therefore that registered more than a 40 percent change (positive or negative) was 13.6 percent of the total number of records (172).

In a situation where the inland fisheries production figure was estimated with relative accuracy at the start of statistical reporting, adjusting backwards might result in a significant error (by effectively increasing the early production level). This assumes that subsequent drifting in the statistics required a subsequent radical revision upwards or downwards to get the production figure back on track. This situation is considered rather unlikely, since it assumes that a rigorous statistical collection system was put in place early on, that was able to provide an accurate early estimate, but which was subsequently unable to maintain accuracy. A more likely scenario is that early statistical reporting under-estimated production and subsequent years compounded reporting errors (due to underestimates

[7] The comprehensive work of the Mekong River Fishery Programme (Mekong Basin areas of Cambodia, Lao PDR, Thailand and Viet Nam) is an excellent example of how consumption estimates can be used as a proxy for fisheries production.

[8] This assumes that some sort of assessment has been made to justify the assumption. In the case of Myanmar's revised statistics, the unofficial explanation given at the time, was that the increase was the result of enhancement, however, no documented assessment exists and the increases appears to be based more on an improved estimate of the fishery.

[9] Back calculation is the process of smoothing an increase (or decrease) backwards along a data set, based on the assumption that an increase was a gradual, annual increase, rather than a sudden jump (or drop).

or over estimates) giving a persistent under/over-estimation of the production with time[10], requiring a significant revision (upwards or downwards) at some later stage. In this case, the backwards adjusting might provide a better estimate of the early production levels and a more realistic trendline.

It is also important to identify falling catch trends. These may be due to general fishery and environmental causes – overfishing, environmental degradation, loss of floodplains and/or connectivity or fishers leaving the fishery for economic reasons. They may also arise from changes in statistical reporting such as reclassification of certain catches or water body types as aquaculture, revision of previous overestimates, elimination of double reporting.

In summary:

- Aggregated statistics at global or regional level often hide individual country trends
- Variations in individual country data are masked through the aggregation of a large number of countries.
- Drifting of estimates or systematic errors in estimations of inland fishery production are likely to occur and are compounded over time. If corrected (adjusted) within a single reporting year without correction of the previous years data, this can seriously distort a trendline.
- Many countries have revised their inland fisheries production statistics since 1950 and these changes can represent significant increases to the national production figure between years.
- The effect of these country adjustments may distort the shape of the trend-line of the region as well as misrepresent that trend of inland fishery production within the individual country.
- Large leaps in the reported data (i.e. over 40 percent increase from previous year) indicate an effect other than natural annual variability in the data.
- It is important to clarify if the continually increasing trend in inland fisheries production is based on sustained, small incremental increases in all countries; or is the result of a series of large, but occasional data revisions of individual countries.

The aim of this analysis was to find if there are large changes (between years) that are significant for a country and further to investigate whether these changes also affect the regional change of that year (for the countries of the Asia-Pacific region).

THE WAY LARGE CHANGES IN INLAND CATCH DATA WERE IDENTIFIED AND HOW THE CATCH DATA WAS ADJUSTED ACCORDINGLY

The global inland fisheries production data (1950-2007) of the FAO FishStat database (FAO FishStat 2009) was the basis for this analysis. The data included *Fish, crustaceans, molluscs, etc.*[11] and all FAO inland water areas. The countries included in the analysis correspond to the APFIC region[12] and these data were analyzed using Excel (Microsoft Office 2003).

[10] The assumption is that increasing populations and consequently, increasing numbers of fishers, inevitably drives increasing inland fisheries production, This does not necessarily mean that the original national production estimates may not have underestimated from the beginning. There is a likely scenario of a combination of initial underestimation and systematic mis-estimation on an annual basis, requiring occasional significant adjustment, when new supporting information becomes available to make a revision. Doing this can significantly distort the trendline.

[11] Excludes production figures for marine mammals, crocodiles, corals, pearls, sponges and aquatic plants.

[12] Countries included: American Samoa, Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Hong Kong SAR, China, Macao SAR, Cook Islands, Fiji Islands, French Polynesia, Guam, India, Indonesia, Iran (Islamic Rep. of), Japan, Kazakhstan, Kiribati, Korea, Dem. People's Rep., Korea, Republic of, Lao People's Dem. Rep., Malaysia, Maldives, Marshall Islands, Micronesia, Federated States of, Mongolia, Myanmar, Nauru, Nepal, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Is., Pakistan, Palau, Papua New Guinea, Philippines, Pitcairn Islands, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan Province of China, Tajikistan, Thailand, Timor-Leste, Tokelau, Tonga, Tuvalu, Uzbekistan, Vanuatu, Viet Nam, Wallis and Futuna Is.

1) Countries with a significant increase in annual production were identified, using ***criterion 1*** *as follows:* Any country reporting a positive change of more then 40 percent, compared with its reported production of the previous year (the 40 percent cut off was considered to be to be well above any naturally driven variability in catch). This identified the number of events of large increases in country production.

2) The countries identified using criterion 1 were filtered according to ***criterion 2*** *as follows:* This second stage filter selected those countries which met criterion 1 and whose inland fishery production change was at least 30 percent greater than the average annual change in global/regional inland fishery production (1951-2007)[13]. This selected those events which would have a likely impact on total regional production and the trend line.

3) The data of the countries identified under criterion 2 were ***backwards-adjusted*** *as follows:* Those countries which were selected using criterion 2, had their production data adjusted backwards using the following formula[14] (creating a new dataset (*Back-adjusted*)):

(**Eq. 1**) $\textit{Back-adjusted}\ \text{Catch}_{\text{year x}} = \text{Original Catch}_{\text{year x}} * (1+\text{Change}^{15}_{\text{Criterion 2 year}})$

Note: Additionally, for this analysis only, events with large negative change were included if their decrease (absolute value) was more than 30 percent of the average regional increase. This adjustment, smoothed out the individual large increases backwards across the data series to remove the effect of a single large increase (or decrease)

4) The new dataset (Back-adjusted) and the original dataset (Original) was further divided by the population of Asia (downloaded from UN[16]), to get a measure of production/person.[17]

Note: Additionally, the average regional population growth rate[18] was used to normalize the catch data from 2007 and backwards (*Back-adjusted PG*) to get an indication of the reliability of the data by decreasing the 2007 value backwards year by year by the specific average growth rate for that year. This last treatment of the data was intended to give an indication of the effect of population growth in the region on the regional trendline[19].

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[13] Many countries with total annual production may report increases of more than 40 percent between years, however, their contribution to the global/regional total may not sufficient to warrant further treatment.

[14] Some countries with several identified changes were subject to several adjustments (i.e. the data was revised several times).

[15] $\text{Change}_{\text{Criteria 2 year}} = (\text{Original Catch}_{\text{Criteria 2 year}} - \text{Original Catch}_{\text{Criteria 2 year -1}}) / \text{Original Catch}_{\text{Criteria 2 year -1}}$

[16] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2008 Revision, http://esa.un.org/unpp, Thursday, August 27, 2009; 8:27:50 PM.

[17] It is recognized that this is an assumption that growth in the population accessing inland fisheries is reflective of the national population. There are of course differences, urban and coastal drift of populations is probably more likely to occur than drift inland to fisheries (although in the case of Tonle Sap, Cambodia, this is the case). Ideally the number of inland fisheries (or populations accessing the inland fishery) would be used., This data however is unavailable across the region.

[18] Five year average growth rate were used: Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2008 Revision, http://esa.un.org/unpp, Thursday, August 27, 2009; 8:27:50 PM.

[19] The purpose of this is to try and illustrate how catches per person may be changing. Using total population as a proxy indicator for total number of inland fishers is done with the assumption that there is a reasonably consistent relationship between number of fishers and total population. Ideally, data would be treated using national population figures and then aggregated. Even more ideally, the data would be treated using the actual number of fishers, although this is a known weakness in the statistics. Assessing the number of inland fishers defies statistics, due to the occasional/part-time nature of many inland fisheries. The use of total national/regional population may be a better estimate when dealing with developing countries with large numbers of rural fishers.

WERE THERE ANY LARGE CHANGES, AND IF SO, WHEN AND WHERE?

Globally, there are inland capture fisheries data for 230 countries or entities in FishStat (FAO FishStat 2009). There has been a steady increasing number of reporting countries throughout the years, from a total of 173 countries in 1950, with rapid 'jumps' in the data at two occasions: a) from 184 countries to 202 (1969-1970); and b) from 202 to 217 (1980-1981). In the Asia and Pacific area, countries reporting inland fisheries production have increased from 44 in 1950 to 54 in 2007. The same two 'jumps' in the number of reporting countries that occurred globally is also found in the Asia and Pacific region, although relatively fewer, with an increase of only 3 countries (all three are major inland fisheries producing countries) at each of the two 'jumps'.[20]

Table 2 The percentage contribution of the change (only increases) for the countries remaining after the different cutoffs (Criteria 1 and 2).

	Sum of change/increase 1950-2007	Change/ regional increase
World increase	8 121 426	
Regional increase	5 688 256	
Criterion 1 change	2 430 161	42.7%
Criterion 2 change	2 050 966	36.1%

The increase in global inland fisheries production between 1950 and 2007 was 8 121 426 tonnes (Table 2), rising from a total of 1 913 101 tonnes in 1950 to 10 034 527 tonnes in 2007. In the Asia and Pacific region, the increase in reported production was 5 688 256 tonnes (Table 2), increasing from 787 311 tonnes in 1950 to 6 475 567 tonnes in 2007 (Figure 1).

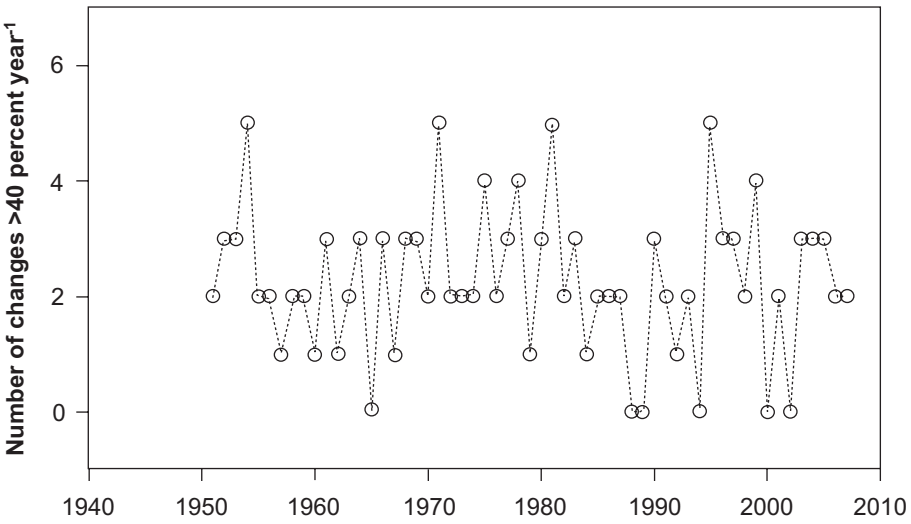
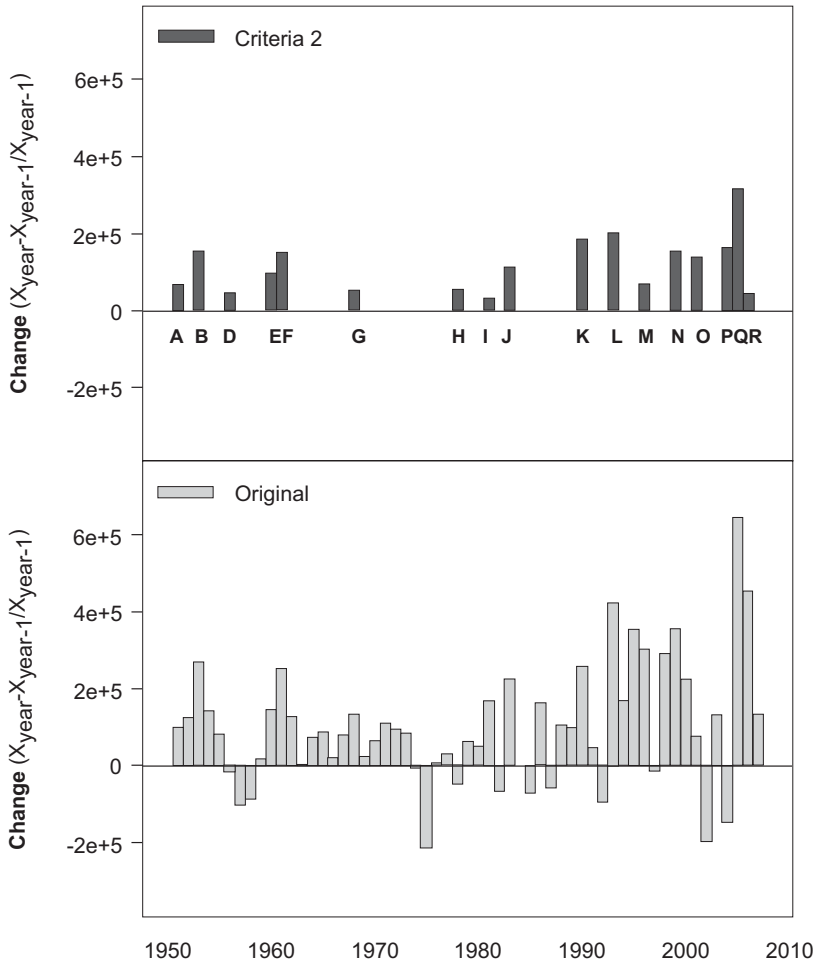


Figure 3 Annual numbers of countries reporting significant increased inland fishery production using criterion 1 (i.e. 40 percent change compared to previous year).

[20] The significance of this is that with the Asia-Pacific region representing such a large proportion of reported global inland fisheries production, the effect of increasing number of countries reporting inland fisheries production does not have a significant effect on the regional total. The same may not be so for other regions.

A total of 128 events were recorded for criterion 1 (a reported production change of more than 40 percent) (Table Annex 1 and Figure 3). This corresponds to an average of 2.26 countries year^{-1} reporting large increases in their inland fishery production data. The total increase in production represented by these 128 changes was 2 430 161 tonnes (Table 2), and corresponds to 42.7 percent of the total increase in the regional inland capture fisheries between 1950 and 2007 (Table 2). The average annual increase in Asia-Pacific inland fisheries production was 99 794 tonnes (*R. Average*).

There were 17 events (out of the 128 criterion 1 events) which were identified under criterion 2; i.e. those having a magnitude that contributed to more than 30 percent of the average increase in regional inland fisheries catch (*R. Average*). The total increase in production represented by these 18 events alone was 2 050 966 tonnes (Table Annex 2) and contributed 36.1 percent of the total regional increase[21] between 1950 and 2007 (Table 1). These 17 events were assigned a separate alphabetic code (A-R) and plotted against total change (positive/negative) and total catch (Figure 4).



Notes: Alphabetic code corresponds to the identified changes and countries as follows: **A**) A (1951, China); **B** (1953, China); **D** (1956, Myanmar); **E** (1960, China); **F** (1961, China); **G** (1968, Philippines); **H** (1978, Philippines); **I** (1981, Cambodia); **J** (1983, Philippines); **K** (1990, India); **L** (1993, India); **M** (1996, Viet Nam); **N** (1999, Cambodia); **O** (2001, Cambodia); **P** (2004, Myanmar); **Q** (2005, India); and **R** (2006, Pakistan).

Figure 4 Changes in reported production that contributed to more than 30 percent of the APFIC regional total change in the same year (top graph); the total regional change for inland capture fishery catches 1950-2007 (bottom graph)

[21] A significant proportion of the total contribution of the 128 events identified in criterion 1 (42.7 percent).

The identified events at the regional level (Table Annex 2 and Figure 4) are evenly distributed throughout the whole time period. The 17 events of increased production are due to changes *in only 7 countries* (Table Annex 2). This is unsurprising, since to qualify under the criteria used for this analysis, the national production needs to be of a scale that would significantly affect the regional total. In addition to the identified 17 events with increasing catch, 3 events of large negative change were identified, namely: China 1957 (-215 900 tonnes); Cambodia 1978 (-43 800 tonnes); and Viet Nam 1994 (-67 252 tonnes). The top three largest individual changes occurred in 2005 (316 456), 1993 (202 618) and 1990 (187 313); all reported by India.

For the APFIC region data, these 17 identified increases and the three negative events (Table Annex 2) were back-adjusted (based on the assumptions and method as described above) to reflect the historic regional trend in inland water capture fisheries production in the Asia and Pacific region. The calculated (*Back-adjusted)* dataset indicates that the initial production in 1950 was around 1 837 189 tonnes, which is 133 percent greater than the original figure from reported data (Figure 5). In the calculated data already in 1974 the production was above 4 700 000 tonnes, a level not reached until 1997 in the original data.

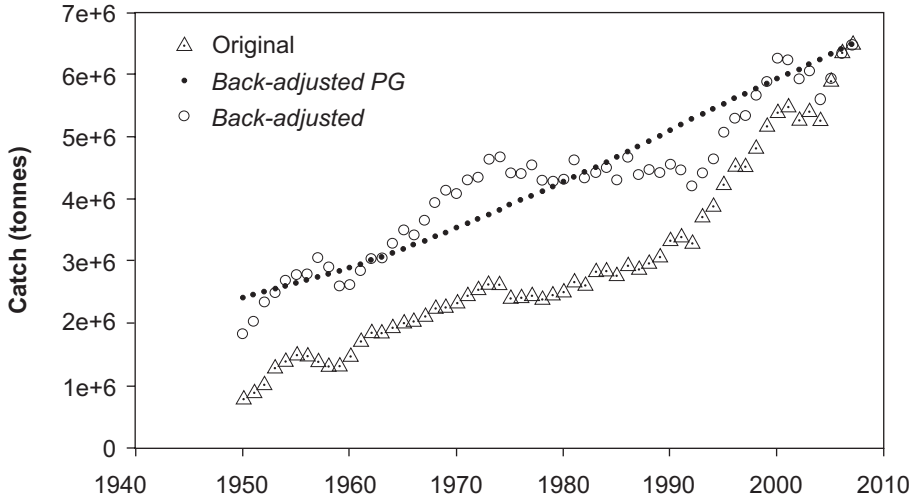


Figure 5 Historically modeled data of inland water capture fisheries catch in the APFIC region based on the changes identified using Criteria 2 and the 3 negative changes identified (*Back-adjusted*) and the data calculated using the 5 year average population growth (*Back-adjusted PG*) and the original inland water capture statistics (Original from countries reported in FAO FishStat).

If the reported inland fishery production for 2007 is back-adjusted using population growth average data (*Back-adjusted PG*), the original production starts at 2 421 671 tonnes in 1950 rising to the 2007 figure of 6 475 697 tonnes. It is interesting to note that this Population Growth adjusted line more closely fits the back-adjusted data than the total regional production based on the data reported to FAO in the FishStat dataset.

Dividing production by the population figure also shows a very different trend between the original data and the adjusted data. The highest production/person calculated from the original data was in 2007, but using the back adjusted data, the highest production per person occurred in 1974 (Figure 6). Even more importantly, the steady increase in catch per person shown by the original data does not occur in the back-adjusted data, which show a general rise up to the 1970s and then a consistent decline thereafter until the 1990s, whereupon is starts to increase again.

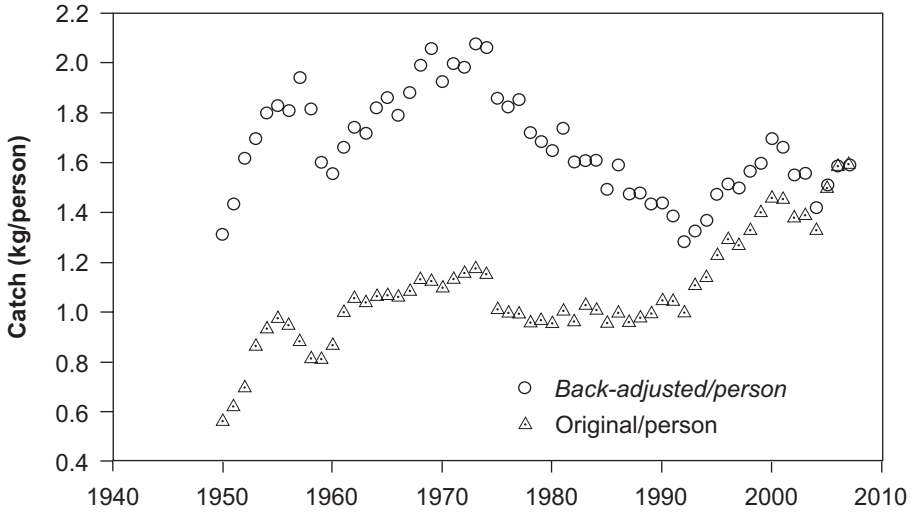


Figure 6 Historically modeled data of inland water capture fisheries catch/person in the APFIC region based on the changes identified using Criteria 2 and the 3 negative changes identified (*Back-adjusted*) and the original inland water capture statistics (Original).

WHAT DOES THIS SHOW US, AND WHAT ARE THE IMPLICATIONS FOR INTERPRETING INLAND FISHERIES TRENDS?

Analysis of the reported inland waters capture production data has shown that individual countries in the Asia-Pacific region have reported an overall annual increase of more than 40 percent, a total of 128 times in terms of national statistics. On average, that corresponds to more than 2 countries per year reporting these very large increases in national production. It is noteworthy that such large increases are a relatively common occurrence and are due to deliberate revision of statistics, rather than a sudden change in the status of a fishery. Despite this, it should be emphasized that not all of these changes will significantly influence the trend of inland fisheries catch at a regional or global level (i.e. many of these countries have a relatively small contribution to total production in the region).

More importantly, out of the 128 events, 17 events were of a magnitude that they were greater than 30 percent of the average regional change (1950-2007) and hence significantly affect the regional trend. These 17 events were confined to 7 countries and represent more than 36 percent of the total change between 1951 and 2007 or 2 050 966 tonnes (Table 2). It can be concluded therefore, that the regional trend in inland catch (Figure 1) is significantly driven by these large changes in only eight countries. Since the APFIC region is the largest inland capture fisheries producer (compared with the other regions of the world), the effects of these events on the APFIC regional trend have a major influence on the global trend. The causes of these large revisions are rarely documented in themselves, but may be mentioned as part of other documents on the status of the inland fishery[22] .

According to the historically-adjusted data, the total regional production has experienced four different periods; 1) a period of rapid growth between 1950 and the mid 1970s; 2) a relatively stable plateau from mid-1970s until the early 1990s; 3) a rapid growth period until the turn of the 20th century[23] ; 4) Then again relatively stable from the year 2000 onwards.

[22] See footnotes 4, 5, 6, 7, 8 for some examples.

[23] The rapid increase in total regional production and thus production/person during the late 1990s can be largely attributed to consistent large increases in reported inland fisheries production in China and Bangladesh.

The inland fishery production data officially reported to FAO (*Original*) show a consistent increase in production throughout the period (1950-2007), and this is also reflected in a steady increase in production/person. As a result, the rate of increased production appears slower, but catch per person almost never declines.

A completely different trend emerges when using the historically back-adjusted data, with rapid increases in production/person until the mid-1970s and thereafter falling production/person, until the mid-1990s where it again started to increase. The decrease in production/person is consistent with anecdotal evidence from numerous field level sources and documented reviews of inland fisheries (e.g. Allen *et al*., 2005; Baran & Myschowoda, 2008; Hap & Bhattarai 2009), all reporting declining catches of fishers. Additionally, the calculated data (*Back-adjusted)* are also more in line with the catch data calculated using the average population increase rate for the region (*Back-adjusted PG*). By assuming a relatively stable relationship between total population and number of fishers, this indicates that that the levels in the back-adjusted data may be more realistic than the original data.

Whilst we recognize that inland fisheries production in the region has almost certainly increased over time, as a result of increasing population pressures, it is also worth noting that there are recent reports of underestimated production in inland capture fisheries in the Asia-Pacific region (Lymer *et al.,* 2008b, Hortle *et al.,* 2007). It can therefore be expected that future revisions upwards of inland fisheries production can be expected from several countries, especially in the Mekong region. The revised estimates for inland fisheries production from these two reports alone corresponds to a significant proportion of the world total inland production.

It is important to note, that these revised estimates do not represent a sudden increase, but almost certainly a systematic and historical under-estimation of the national production. The implications of this are that we must avoid falling into the trap of assuming that production is increasing, when we are really only seeing a re-adjustment of the baseline and that from some countries at least, there may actually be a trend of decline in the fishery being masked by the aggregation of catches and production of multiple countries.

This review is, in effect, a 'thought experiment' using arbitrary criteria (the 40 percent increase in criterion 1 and 30 percent change in criterion 2) and simple back-adjustment of the data. This did not substantively take into account large negative revisions in criterion 1 analysis (Figure 3), such negative changes are fewer but could also significantly affect the dataset. An important consideration is that we have not distinguished between data reported by countries and FAO estimates. The population data used for the calculation in production/person included "all Asia", whereas the production data use did not include all of these countries, hence the absolute catch level is slightly lower than could be expected. However, the trend in population growth and hence the trend in the calculated production/person can be considered a reliable reflection of the regional situation[24] .

A final comment on the rapid rise in inland fishery production during the latter half of the 1990s is worth mentioning. Although inland fisheries are generally considered to be under-reported for the reasons provided earlier in this review, there are a number of reasons why production increases may be reported. The stocking or enhancement of inland fisheries can significantly increase their productivity leading to reports of increasing production. Such increases may be genuine or artifacts from the optimism generated from national programmes to increase production leading to over-estimates of impacts. In terms of highly managed culture-based fisheries (with a degree of ownership of the stocked fish and a relatively closed water body) these should be reported as aquaculture. In the case of commercialization of enhanced fisheries, the actual production increases may be real and this is an

[24] This analysis could be strengthened by using the total national population data of those countries for which inland fishery production is reported.

area which also requires further attention, since the production increases from inland wild fisheries is driven by pressure and "fishing down the food chain", whereas productivity increases from enhanced fisheries could also be driven by the enhancement regime. The two do not exist in isolation and both of these factors may be occurring simultaneously in adjacent fisheries or even within some fisheries. The changes that result from these drivers is gradual, however, the decision to revise statistics based on one or other trend may be made after a period of time or following an assessment or some other source of updated information.

Inland fisheries rarely involve international political and territorial disputes, in contrast to some marine fisheries. The multi-stakeholder issues surrounding freshwater use (for power, irrigation, domestic consumption, leisure) also means that fisheries services may not be valued highly and as a consequence, little effort and resources have been allocated to information gathering in, and management of, inland fisheries. There is a growing awareness that, in certain parts of the world, inland fisheries can be a major source of protein and livelihoods which sparked recent interest in these fisheries. Furthermore, the common lack of inclusion of occasional fishing catches and catches from recreational fishing (Cowx & Cooke 2005) and the fact that many countries still encounter great difficulties in managing and funding the collection of inland capture statistics are highlighted as major problems by FAO. In addition, the very poor species breakdown reported by many countries risks bias trend analysis by species or species groups of the inland catch data. In 2006, global inland catches classified as "freshwater fishes not elsewhere included"[25] again exceeded 50 percent (57.2 percent) of the global catch and about 74 percent in Asia and the Pacific region. A most worrying trend is that these figures are actually increasing both globally and in the region.

In conclusion, this thought experiment highlights the need to be careful when drawing conclusions about the trend of inland water capture fisheries catches at the regional level (Asia-Pacific) and potentially also at the global level. The simple image of an increasing trend in inland capture fisheries production, belies complex drivers and country and fishery specific contexts. A clearer understanding of how these drivers are affecting the country and regional production trend is critical when considering the potential for further development of inland fisheries. This underscores the importance of taking a holistic view of inland fisheries management (i.e. ecosystem approaches).

[25] This refers to an aggregation of many freshwater species.

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Table Annex 1 – Data for regional change, criterion 1 and criterion 2 by year

Year	Total region change (from previous year)	Criterion 1		Criterion 2	
		Number of countries	Sum of change	Number of countries	Sum of change
1951	99 523	2	92 763	1	68 768
1952	123 384	3	22 250	0	0
1953	262 580	3	160 601	1	154 001
1954	123 111	4	35 520	0	0
1955	87 538	2	17 800	0	0
1956	-15 169	2	64 300	1	47 000
1957	-80 399	1	200	0	0
1958	-85 751	2	480	0	0
1959	17 774	2	340	0	0
1960	144 909	1	96 664	1	96 664
1961	251 865	3	174 262	1	150 468
1962	128 206	1	201	0	0
1963	2 575	2	60	0	0
1964	73 002	3	1 806	0	0
1965	87 727	0	0	0	0
1966	20 496	3	300	0	0
1967	79 697	1	100	0	0
1968	133 447	3	53 911	1	52 600
1969	23 463	3	3 246	0	0
1970	64 537	2	2 305	0	0
1971	109 870	5	34 369	0	0
1972	95 582	2	582	0	0
1973	83 497	2	882	0	0
1974	-5 192	2	4 693	0	0
1975	-212 716	4	13 609	0	0
1976	7 177	2	8 674	0	0
1977	30 484	3	12 041	0	0
1978	-46 734	4	56 878	1	56 530
1979	62 151	1	5 028	0	0
1980	50 176	3	3 942	0	0
1981	167 389	5	54 157	1	32 140
1982	-66 864	2	2 045	0	0
1983	222 986	3	112 276	1	111 985
1984	2 127	1	764	0	0
1985	-70 755	2	4 115	0	0
1986	162 262	2	5 159	0	0
1987	-57 829	2	9 108	0	0
1988	104 716	0	0	0	0
1989	98 149	0	0	0	0
1990	258 227	3	206 047	1	187 313
1991	47 353	2	18 152	0	0
1992	-94 682	1	6 223	0	0
1993	422 607	2	202 722	1	202 618
1994	169 075	0	0	0	0
1995	353 965	5	11 505	0	0

Year	Total region change (from previous year)	Criterion 1		Criterion 2	
		Number of countries	Sum of change	Number of countries	Sum of change
1996	301 205	3	77 505	1	70 247
1997	-12 479	3	2 907	0	0
1998	291 451	2	149	0	0
1999	355 332	4	177 082	1	155 300
2000	223 660	0	0	0	0
2001	76 891	2	139 459	1	139 400
2002	-197 220	0	0	0	0
2003	129 558	3	1 959	0	0
2004	-146 275	3	165 856	1	164 120
2005	642 179	3	317 410	1	316 456
2006	450 132	2	46 756	1	45 356
2007	138 286	2	998	0	0
Total	**5 688 256**	**128**	**2 430 161**	**17**	**2 050 966**
Average		**2.25**		**0.30**	

Table Annex 2 – Country data for Criterion 2

Country	Sum of changes (tonnes)	Number of changes
China	469 901	4
India	706 387	3
Philippines	221 115	3
Cambodia	326 840	3
Myanmar	211 120	2
Viet Nam	70 247	1
Pakistan	45 356	1
Total	**2 050 966**	**17**

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