

**Appendix A Land use changes within the Agno watershed (1986-1993)**

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**Introduction**

The data sets used for the determination of land use change were compiled from: the 1995 JAFTA report for the more recent land use/cover of the Agno watershed; the 1986 and an indeterminate date but presumably before 1990 Soil/Land Resources and Evaluation Project reports of the Bureau of Soils and Water Management, and the Study of Agno River Basin and Flood Control report by JICA in 1991 for the earlier data sets.

The spatial coverage for the land use/cover data includes the three provinces that can roughly fit within the Agno Watershed boundary as delineated in the JICA report. Benguet Province occupies in part the headwaters of the Agno Watershed. Pangasinan covers the central and low-lying areas, but more than half of its administrative boundary extends beyond the watershed divide to the west. Tarlac Province occupies the southern portion of the watershed but a third of its boundary also extends beyond the southeastern watershed divide. The area of the Agno Watershed is 7,460 km<sup>2</sup> while the aggregate area of these three provinces is 1,096,458 hectares or 10,964.58 km<sup>2</sup>. The delineated area of the Agno watershed is only about seventy percent of the size of the three provinces.

**Data Lineage**

For the provinces of Benguet and Tarlac, the BSWM and JAFTA data were used for calculation of land use/cover change through time. The JAFTA data were generated from the image processing of the Landsat TM image using the scenes from the paths and rows, 116-48 and 116-49 captured in April 2, 1993. The BSWM data as presented in the Soils/Land Resources Evaluation Project (S/LREP) report were generated through aerial photograph interpretation and field surveys. Report for Benguet does not specify the dates and acquisition of aerial photographs, the duration of the field survey and the publication and date of the report. The LREP for Tarlac was issued in 1986 but without any reportage on the date of acquisition of the aerial photos and duration of field survey. Nevertheless, it is assumed that these data sets were generated at the latest, in 1986.

The land use/cover change data for the province of Pangasinan were entirely taken from the 1991 Study of Agno River Basin Flood Control report of JICA. The lineage of JICA data is the 1983-1987 Multi-Year Human Settlement Plan of Region I, 1987-1992 Mid-term Ilocos Region Development Plan, Regional Development Council Report of Region I, 1985 Socio-Economic Profile and the compilation of the Department of Agriculture in the provinces of Tarlac and Pangasinan. The JICA data did not provide a definition or detailed description for each land use categories but it is assumed that land use classes are similarly defined as the other data sets.

The JAFTA and BSWM employed different nomenclatures in designating land use/cover types, although certain classes have similar descriptions. For Benguet and Tarlac data sets to be comparable, similarly described or closely defined classes in both sets were grouped. Also, in order to calculate land use changes for the whole region, land use classes were reclassified to conform to the data set that has the least information resolution. Since the JICA land use categories used a more regional approach in its classification scheme, unlike the more detailed classification of BSWM and JAFTA, the JICA scheme was then used as template for reclassification but with some modifications (refer to Table A1). Note that the JICA land use/cover data do not have shrub land or brush land in its classification. It is also assumed that this category is included in the grassland class. Swamps and fishpond is grouped with the wetland class, and mining, with the bare land class. The JAFTA data included clouds and shadow classes that were present only in the Benguet. These classes were disregarded since they contributed only 0.3% of the province and 0% of the study area.

**Table A1. Land use/cover nomenclatures or categories used in the various data sets**

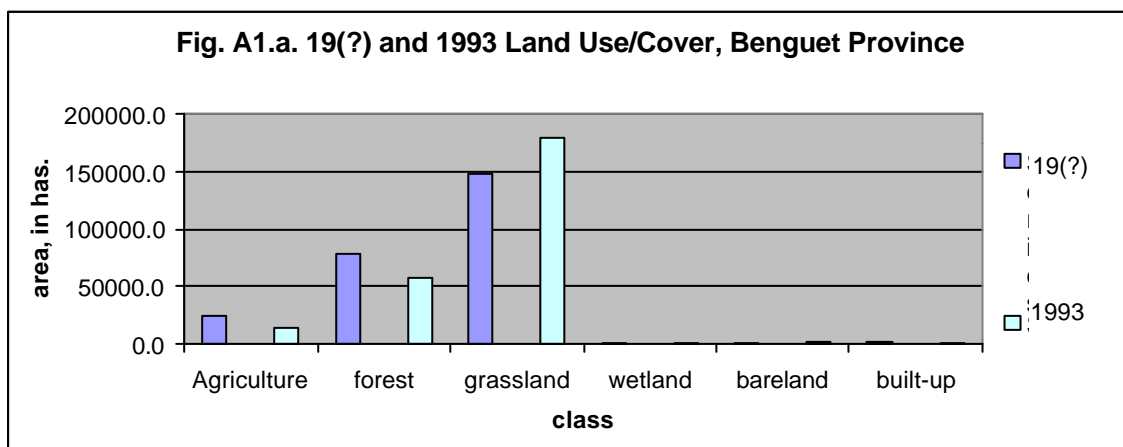
| This report       | BSWM (S/LREP)  | JAFTA  | JICA   |
|-------------------|--|--|--|
| Forest land       | Forest   | Old growth<br>Mossy<br>Residual forest<br>Sub-marginal forest<br>Pine forest | Forest   |
| Agricultural land | Irrigated rice paddies, wet season rice paddies, corn, root crops, vegetables, coffee, tobacco, cotton, coconut, fruit trees, banana, maguey | Agricultural area<br>Coconut<br>Other plantation                             | Agricultural land<br>Irrigated paddy<br>Rain-fed paddy<br>Others |
| Grassland         | Shrubs, ipil-ipil, grasses, pasture lands, bamboo  | Grassland<br>Reproduction brush  | Grassland  |
| Wetland           | Nipa, mangrove, rivers, fishpond, salt beds, swamp, reservoir, filling pond  | Mangrove<br>Water body   | Fishpond<br>Swamps   |
| Bare land         | Sand and gravel areas, mine pit site, riverbed, river wash   | Bare/rocky land  | Mining<br>Bare land  |
| Built-up area     | Residential and commercial areas   | Built-up area  | Built-up/others  |

**Discussion**

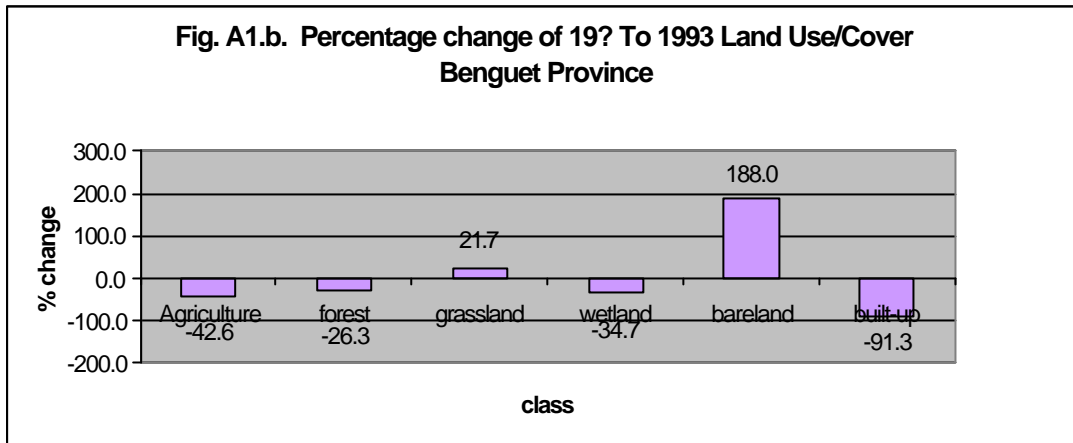
**Land use changes in the provinces of Benguet, Tarlac and Pangasinan**

Benguet

The eastern half of Benguet occupies in part the northern headwaters of the Agno Watershed. Here, agricultural land encompasses the third most extensive land use/cover classes, which has an aggregate area of a few ten thousands of hectares. From an indeterminate date to 1993, there was a contraction of 10,275 hectares that ate up 42.6 % of the previous area. Forestland is the second most extensive area which is some ten thousands of hectares. For the inclusive years it showed the largest magnitude in area reduction of 25% of the province’s original size. Grassland is the most extensive class, with areas of approximately a hundred hectares. It showed an expansion of 32,054 hectares, representing 21.7% increase from the earlier data. Wetland occupies some hundreds of hectares, which is one of the least extensive classes in the province. It decreased by 269 hectares, which is 34.7% of previous area. Bare land comprises just a few thousand hectares. In 1993, it expanded by 1,903 hectares, about twice its earlier size. Of the six land use/cover classes, built-up area suffered the greatest loss in terms of percentage change while showing the least reduction in size at 254 hectares. Built-up area is nearly wiped out with only less than 10% of its earlier area remaining as of 1993 (refer to Table A2. a and Figure A1. a, b).

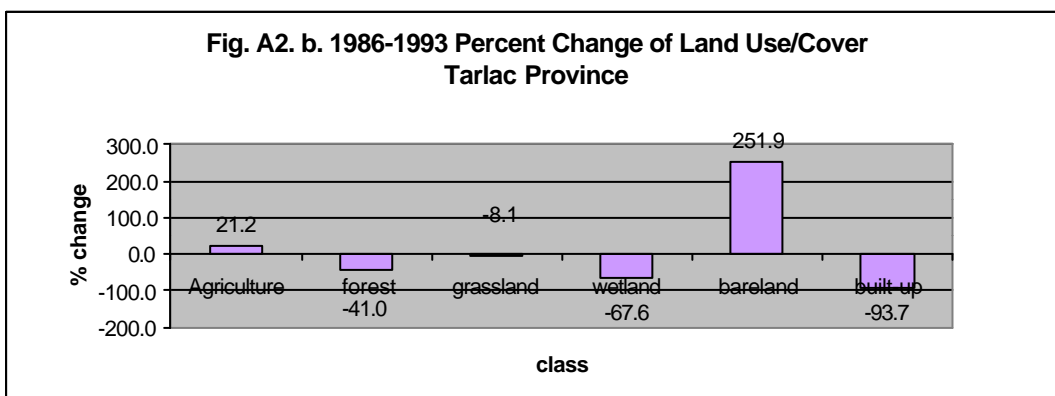
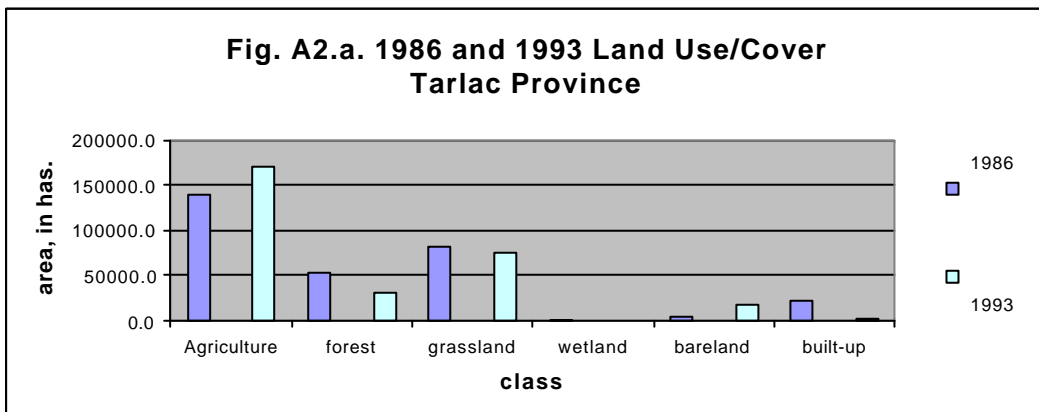


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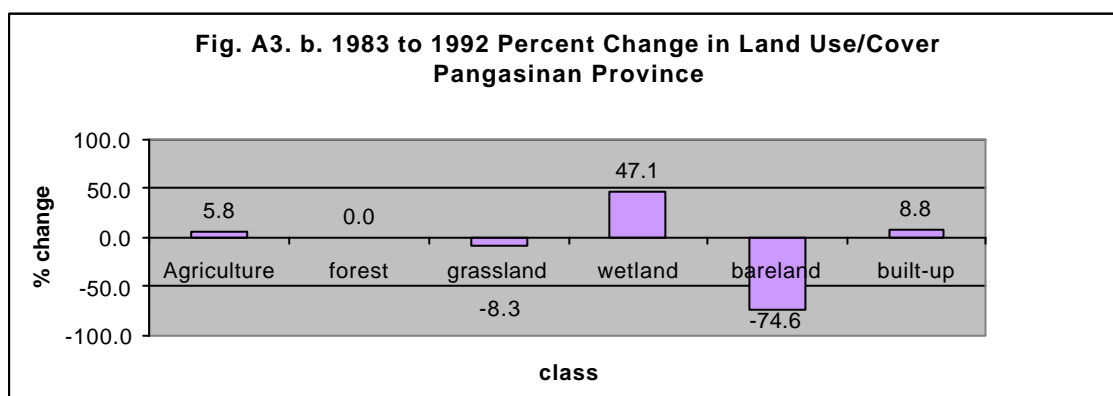
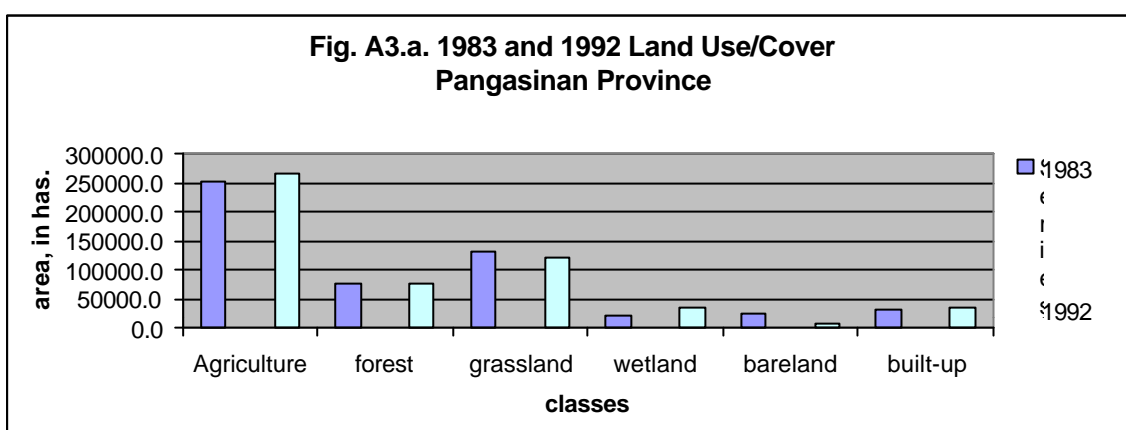
**Tarlac**

Tarlac Province is located on the southern section of the Agno watershed. Unlike the north, Tarlac is situated in mostly gentle terrain. Agricultural land is the largest class in the province that has total area of a few hundred thousand hectares. From 1986 to 1993, agricultural land has encroached by 29,728.2 hectares or 21.2 % of the 1986 area. Grassland also expanded, in the order of some ten thousands of hectares. By 1993, the grassland class had decreased by 6,714.5 hectares, approximately a tenth of the 1986 area. Wetland occupies the smallest area in terms of size, which is around a few hundred hectares. In a span of seven years, the wetland class contracted by 238 hectares or two thirds of its previous size. The bare land class of Tarlac experienced the highest percentage of increase from 5,387 hectares in 1986 to 18,957 hectares in 1993. The change represents 251.9% of the earlier data. The built-up class of Tarlac showed the same trend as the built-up class of Benguet province, which also showed a loss of greater than 90 percent of the previous area (refer to Table A2. b and Figure A2. a,b).



Pangasinan

Pangasinan is situated in the low-lying areas of the Agno watershed. Like Tarlac, its agricultural land use/cover class is the most extensive in the province. The sum of its areas is a few hundred thousand hectares. From 1983 to 1992, the agricultural land use/cover increased by 14,700 hectares, a modest growth of 5.8%. Forestland is the third most extensive, but showed no change in area during the period. Next to agriculture, grassland covered the largest area in the province with an aggregate size of a little more than a hundred thousand hectares. By 1992, its area was reduced to 10,900 hectares, which is less than a tenth of the 1983 size. The wetland area of Pangasinan is the largest among the three provinces because of its location in the Agno watershed. The total size is in the order of few ten thousand hectares. By 1992, the wetland class was 10,700 hectares, or almost half the 1982 area. The bare land class showed the most drastic change in the province. For a period of nine years, it suffered a 74% of earlier area. The built-up class occupies a total area of approximately few thousand hectares. By 1993 built-up area expansion is 8.8% of 1982 size (refer to Table A2. c and Figure A3. a,b).



**Table A2. Land use changes for the three provinces of the Agno watershed.**

a. Benguet Province

| Class       | 19(?)<br>(area in has.) | %     | 1993<br>(area in has.) | %     | Change<br>(in has.) | %<br>change |
|-------------|-------------------------|-------|------------------------|-------|---------------------|-------------|
| agriculture | 24098.0                 | 9.5   | 13823.0                | 5.4   | -10275.0            | -42.6       |
| forest land | 78034.0                 | 30.6  | 57521.0                | 22.5  | -20513.0            | -26.3       |
| grassland   | 147814.0                | 58.0  | 179868.0               | 70.4  | 32054.0             | 21.7        |
| wetland     | 776.0                   | 0.3   | 507.0                  | 0.2   | -269.0              | -34.7       |
| bare land   | 1012.0                  | 0.4   | 2915.0                 | 1.1   | 1903.0              | 188.0       |
| built-up    | 2931.0                  | 1.2   | 254.0                  | 0.1   | -2677.0             | -91.3       |
| clouds      | data from survey        |       | 653.0                  | 0.3   |                     |             |
| shadow      | and aerial photo        |       | 113.0                  | 0.0   |                     |             |
| total area  | 254665.0                | 100.0 | 255654.0               | 100.0 |                     |             |

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**Table A2 (cont.).**

b. Tarlac Province

| Class       | 1986<br>(area in has.) | %     | 1993<br>(area in has.) | %     | change<br>(in has.) | %<br>change |
|-------------|------------------------|-------|------------------------|-------|---------------------|-------------|
| agriculture | 140129.8               | 46.0  | 169858.0               | 56.9  | 29728.2             | 21.2        |
| forest land | 54136.0                | 17.8  | 31920.0                | 10.7  | -22216.0            | -41.0       |
| grassland   | 83038.5                | 27.2  | 76324.0                | 25.6  | -6714.5             | -8.1        |
| wetland     | 352.0                  | 0.1   | 114.0                  | 0.0   | -238.0              | -67.6       |
| Bare land   | 5387.0                 | 1.8   | 18957.0                | 6.3   | 13570.0             | 251.9       |
| Built-up    | 21841.7                | 7.2   | 1372.0                 | 0.5   | -20469.7            | -93.7       |
| Total area  | 304885.0               | 100.0 | 298545.0               | 100.0 |                     |             |

c. Pangasinan Province

| Class       | 1983<br>(area in has.) | %     | 1992<br>(area in has.) | %     | change<br>(in has.) | %<br>change |
|-------------|------------------------|-------|------------------------|-------|---------------------|-------------|
| Agriculture | 251800.0               | 46.9  | 266500.0               | 49.6  | 14700.0             | 5.8         |
| Forest land | 76500.0                | 14.3  | 76500.0                | 14.3  | 0.0                 | 0.0         |
| Grassland   | 130800.0               | 24.4  | 119900.0               | 22.3  | -10900.0            | -8.3        |
| Wetland     | 22700.0                | 4.2   | 33400.0                | 6.2   | 10700.0             | 47.1        |
| Bare land   | 23200.0                | 4.3   | 5900.0                 | 1.1   | -17300.0            | -74.6       |
| Built-up    | 31800.0                | 5.9   | 34600.0                | 6.4   | 2800.0              | 8.8         |
| total area  | 536800.0               | 100.0 | 536800.0               | 100.0 | 0.0                 | 0.0         |

d. Land use changes for the Agno watershed

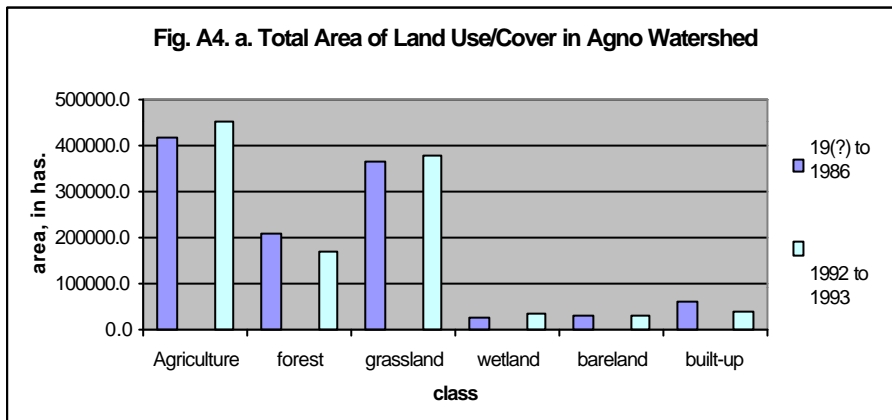
| Class       | 19(?) to 1986<br>(area in has.) | %     | 1992 to 1993<br>(area in has.) | %    | change<br>(in has.) | %<br>change |
|-------------|---------------------------------|-------|--------------------------------|------|---------------------|-------------|
| agriculture | 416027.8                        | 37.9  | 450181.0                       | 41.3 | 34153.2             | 8.2         |
| forest land | 208670.0                        | 19.0  | 165941.0                       | 15.2 | -42729.0            | -20.5       |
| grassland   | 361652.5                        | 33.0  | 376092.0                       | 34.5 | 14439.5             | 4.0         |
| wetland     | 23828.0                         | 2.2   | 34021.0                        | 3.1  | 10193.0             | 42.8        |
| bare land   | 29599.0                         | 2.7   | 27772.0                        | 2.5  | -1827.0             | -6.2        |
| Built-up    | 56572.7                         | 5.2   | 36226.0                        | 3.3  | -20346.7            | -36.0       |
| Total area  | 1096350.0                       | 100.0 | 1090233.0                      | 99.9 |                     |             |

Totals for the Provinces within the Agno watershed

The most extensive land use/cover classes within the Agno watershed are agricultural land, grassland, and forestland. Their sizes range from 200,000 to 400,000 hectares, while the land use/cover classes that occupy smaller areas are built-up, wetland and bare land. The magnitude of these classes is around a few ten thousand hectares. For the entire region, agricultural land contributed the largest land use expansion at 34,153 hectares followed by grassland at 14,439 hectares and wetland at 10,193 hectares. In terms of previous area, forestland showed the greatest reduction at 42,729 hectares, followed by the built-up area, and bare land at 1,827 hectares. The calculated values for built-up areas must be treated with caution since the more recent land use data for Benguet and Tarlac showed an unrealistic decrease of more than 90% of previous size. The trend for built-up areas is usually increasing with the growing demand for residential and commercial land uses with time, unless seriously affected by natural disasters. While data used for land use/cover change calculation include within its period the eruption of Mount Pinatubo, built-up areas within the Agno watershed, even those in Tarlac, were far from the influence of the volcano. The calculated change for the built-up class may reflect different methodology or procedure in delineating land use/cover. The S/LREP data employed survey and aerial photo interpretation whereas the JAFTA data used satellite image interpretation. Since some built-up areas are small, discrete, not continuously

distributed and in close association with vegetated land uses, these features may not be pronounced in the image data, thus may have not been accounted for.

In terms of percentage change from previous area, wetland class increased by 47.1%. Pangasinan contributed the largest area as well as the positive growth of this land use/cover class for the whole region despite the negative percent change for the other two regions. Agriculture showed a modest growth of 8.2% despite contributing the largest change in terms of size. Like the wetlands, Pangasinan has the largest share in the sum of all agricultural lands in Agno Watershed. A 4% increase occurred in the grassland areas which is very extensive in the provinces of Pangasinan and Benguet. Disregarding built-up area, the class that showed the greatest negative change is the forestland at 20.5%. The provinces of Benguet and Tarlac experienced contraction of forestland. As noted earlier, Pangasinan did not record any change in this class, despite its cities and many of its municipalities serve as settlement hubs within the Agno Watershed. Bare land experienced the least negative change at 6.2%. Per province, this class exhibited large magnitudes of positive or negative percentage change such as the doubling trend for Benguet and Tarlac, and a reduction by about 75% for Pangasinan. For the whole region, land use/cover change yielded less than 10% contraction for the Agno watershed (refer to Table A2. d and Figure A4. a,b).



**References**

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