Assessment of Environmental Noise due to Aircraft Operation at the CORFU International Airport according to the 2002/49/EC Directive and the new Greek National Legislation

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Summary
Environmental Noise annoyance - especially from airports operation - is widely accepted as an end-point of environmental noise that can be taken as a basis for evaluating the impact of noise on the exposed population. CORFU (island of Corfu - Greece) International Airport is one of the most developing, functional airports in Greece, and constitutes one of the preferred tourist destination in southeastern Europe. Environmental Noise from aircraft movements at the Airport is a crucial environmental factor of the urban environment and life the quality especially in Southern European countries where climatic conditions favors outdoor activities & the night life. The ministry of the Environment, Energy & Climate Change of Greece (YPEKA) in collaboration with the University of Thessaly completed a comparative Study on Aircraft Noise - according to the European Directive 49/2002 (ED 2002/49, 2002) - for the 2013 Strategic Noise Maps (SNM) for both EU indicators L_{den} and L_{night} using appropriate software and relevant data bases e.g. INM & AzB08 (CadnaA). A full questionnaire analysis was also completed in order to evaluate population exposure and reaction to eventual annoyance climate.

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1. Elements of methodology

1.1. The SNM 2013 of Corfu city greater area

In the frame of the Strategic Noise Mapping (SNM) program of the Greek Ministry of the Environment the L.T.E.A. of the University of Thessaly [1] completed a comparative Study on Aircraft Noise - according to the European Directive 49/2002 [2], in Corfu city greater area (see figure 1), including an extended evaluation of the aircraft noise impact at the south-east area of the city adjacent to the International airport "Ioannis Capodistrias". This area is a major touristic zone with. Kanoni and Pontikonisi welcoming every summer season a large number of tourists. In consequence, airport operations e.g. landing taxi and take-off procedures consists a rare attraction for tourists but also an important annoyance factor. The main issue is how airport activities are perceived in this area of the city? The aim of the study is to describe the qualities of the sound environment in this place and try to understand the role of the airport in this specific context. In figure 3 the results of the SNM 2013 for both noise indices L_{den} & L_{night} for the total Corfu city greater area are presented. Within the SNM calculations the above subarea adjacent to the Int. Airport was analysed (see subarea blue boundaries in figure 2 hereafter). The relevant subarea is located in the south area of the Corfu city peninsula in considerable distance from the historical city centre. On the west side, the subarea overlooks the airport while in its eastside it overlooks the sea. The urban tissue is not quite dense and a lot of green areas & urban parks with vegetation growing in between buildings are present. This area offers many hotels, coffee places, apartments, rooms to rent and various recreation areas. Some residential buildings for permanent residents are also present.

The west side, is facing the airport and the closest habitations are located less than 500 m from the runways. What are the influences of airport operations on the perception of the sound environment by both tourist & inhabitants in the subarea? It is expected that airport operation alters significantly the balance of the acoustic environment. How one may suggest measures aiming at reducing the discomfort of an aircraft passage or taxiing?

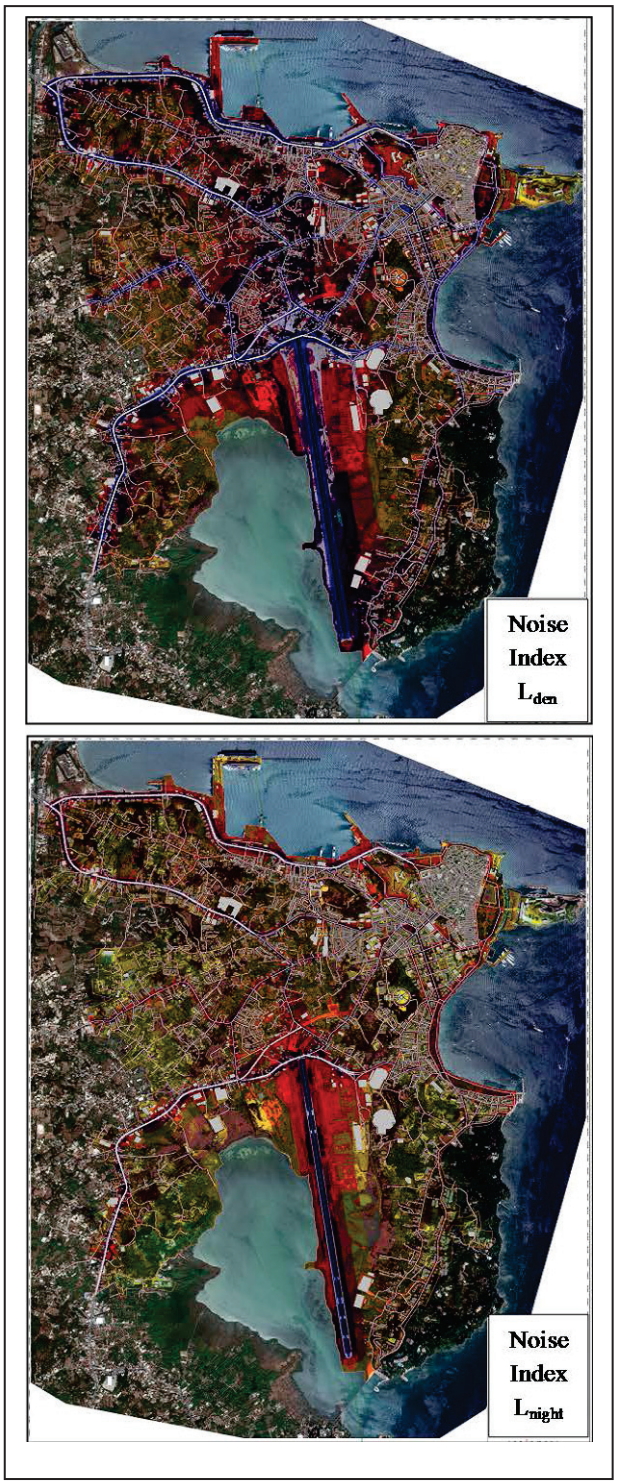


Figure 1. Strategic Noise Map of Corfu (road & airport noise combined – CadnaA software)

Figure 2. Subarea in Corfu city (blue doted line)

In order to evaluate the accuracy of SNM VS measurement data, a 24hrs acoustic measurements campaign was also executed as per other airports [3]. Measured results compared to calculations based on the same parametrical assumptions proven to have a significantly high correlation coefficient R^2 varying from 0,956 for L_{den} to 0,923 for L_{night} (see figure 3).

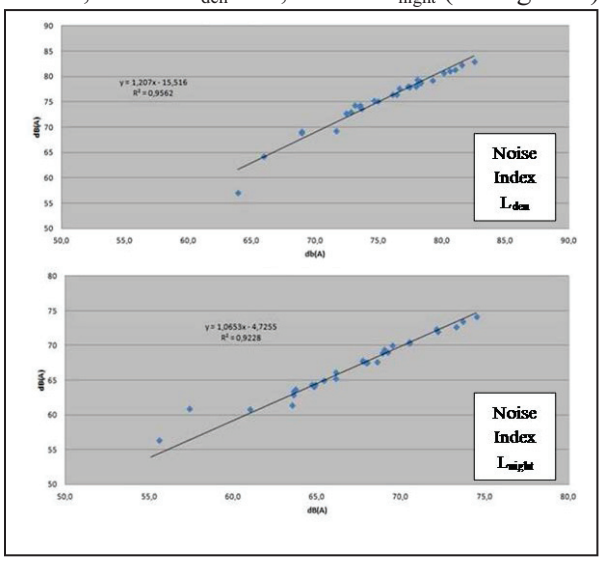


Figure 3. Correlation coefficient – Measured VS Calculated values for L_{den} & L_{night} indices at SNM of Corfu city greater area (road & aircraft noise combined)

1.2 Interviews in situ

A series of interviews (in GR, ENG and FR languages) was completed mainly among the touristic population, including also people working in the subarea and the residential population in order to understand their perception of the existing sound environment [4]. The questionnaire had semi-directive form and composed by approximately 20 different items as shown in Table 1. In Corfu subarea, 119 people were interviewed in the period from Monday, the 2nd of June 2014 until Wednesday, the 4th of June were airport operation conditions were rather representative for the extended summer period in the island.

Table I

	QUESTIONS
1.	Here, you would say that we are **In town on the sea side? On the country side? (Reasons—why ?)** **1 2 3 4 5 6 7**
2	Can you hear traffic noises; Is it disturbing (on a scale from 1 very much to 7 not at all and why ? **Very much vs Not at all** **1 2 3 4 5 6 7**
3.	Can you hear the sounds of the neighbourhood here? How would you evaluate it? **Vivid** vs **Disturbing** **1 2 3 4 5 6 7** **(Kids, animals, party, discussions, voices, etc.?)**
4	In general, you would say that the sound environment is and why? **Dynamic** vs **« Dead »** **1 2 3 4 5 6 7**
5	You would say that the sound environment is calm with small intervals of noise (1) or noisy with small intervals of silence (7) and why ? **1 2 3 4 5 6 7**
6	Which sounds mark the place where we're now (in order of priority)
7	Which ones are disturbing? Why? (sound sources list)
8	Where is your favourite place in the area and why? (mark on the map)
9	Have you noticed any sounds that are repeated the same time every day or every morning, afternoon, night..? (Churches, shops, kind gardens, garbage trucks, etc.)
10	If you could pick up ONE sound that characterizes the place, which one would you choose? (Sources and time?)
11	Does this sound belong to the place where we are now or can it be heard from others places as well? (sources and times)
12	Have you noticed any sounds that have disappeared? (Sources and time?)
13	Do you remember any specific sound events when you heard a specific sound? (when?)
14	In this area, is there any place with silence? Where and why? (mark on the map)
15	Can you hear the night life? Music? Conversations? Pedestrians? Motorbikes? Is it disturbing? **Very much** vs **not at all** **1 2 3 4 5 6 7**
16	Can you describe to me When and What sounds you hear from the airport? (Land off or land in ? day and?or night ? windy day ? sound sources descriptions ?);
17	Is it disturbing ; **Very much vs not at all** **1 2 3 4 5 6 7**
18	What else can we hear when we don't hear sounds from the aircrafts/ airport;
19	Is this the first time for you in Corfu? In this hotel? How many days are you going to stay?
20	What can you see from your room? Is it opened in the direction of the airport? Do you know if there is a place (rooms) where you can hear less the airplane noises?

2. Results

2.1. 24h acoustic measurements in the subarea

24h acoustic measurements were executed, in the subarea, during the interviews, in the locations, presented in the figure hereafter. The results are described in the following table II.

Figure 4. 24h acoustic measurements locations in Corfu subarea.

Table II

Measurements locations (no)	L_{den} dB(A)	L_{day} [07:00 - 19:00] dB(A)	L_{night} [23:00 - 07:00] dB(A)
27	65,9	65,1	55,6
28	63,9	57,1	55,1
29	78,7	69,6	73,1

An additional 24h acoustic measurement location (no 29) was also added located inside the airport boundaries providing a valid reference. Locations 27 and 28 were selected as the most representative to the airport noise exposure:

- the ROYAL BOUTIQUE HOTEL at a balcony overlooking the airport (n°27)
- the DIVANI CORFU PALACE HOTEL at a balcony overlooking the airport (n°28)

Both locations were chosen due to the dominant influence of the air traffic on sound environment with the road traffic noise to be rather limited due to low traffic during all day, and a complete absence of both industrial of craft hand activities in the subarea. The recorded noise is mainly due to the airport activities correlated with landing taxing and taking off procedures. During a typical weekday within the tourist season, L_{den} is approximately equal to 66dB(A) corresponding to a rather reduced value given the proximity to the airport. Aircraft operation events create however larger emergences but on average, their impact is limited for exposed populations. Measurements also show that the noise level is relatively constant during the day and in the

evening. At location 27 of the runway end is about 65 dB (A). This remark is not valid for the location 28 that is located near the aircraft parking area. During the evening, noise levels show a significant difference compared to day values e.g. L_{day}=57.1 dB (A) and $L_{evening}$=63dB (A). For these representative noise measurement locations, when no plane activity is monitored during the night, ambient noise levels are really quiet (with the relevant Leq values (1s) to vary between 35-40dB(A). Night indices are really explicit: for the location 27 L_{night}=55,1 dB(A) representing rather low values given to the proximity of the airport.

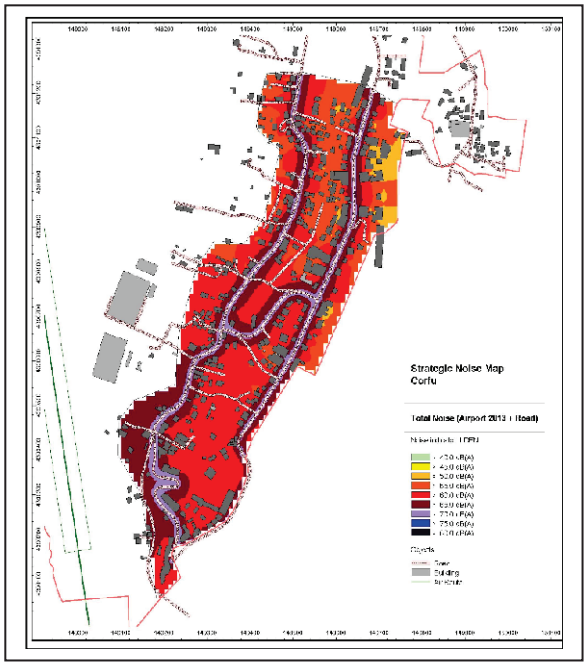
2.2 Analysis of SNM calculations in the subarea (CadnaA software)

In order to complete the analysis the SNM was calculated for the subarea using the CadnaA software and the AzB99 database. Both noise indices L_{den} and L_{night} results are given below.

The SNM calculation results are similar to the measurements. The entire subarea is exposed to rather low noise levels during day and night. During the day, the majority of the area is exposed to L_{den} values between 55 and 60 dB(A). Only at the proximity of the road network, we detect some higher values around 65 dB(A). Noise values fall down by 10 dB(A) at night giving L_{night} values between 45 and 55dB(A). It is interesting to note that both indexes SNM are rather uniform from the point of view of the spatial distribution of sound levels, despite of the quite significant topographical variations of the terrain and the shape and orientation of some buildings.

In other words, there are no zones that are noisier or quieter due to the airport in the west side of the subarea. The air traffic is therefore responsible for the sound levels on the subarea, given to the fact that, the whole of the subarea, is fully exposed to aircraft operation with no acoustic shade) present.

However the study area is generally very quiet in terms of average equivalent noise indices regardless the airport operation, with the road traffic only slightly responsible for the sound levels observed. Even though an aircraft operation event (mainly take-off and/or landing) constitutes a powerful acoustic emergence, the average overall airport impact, do not affect long-term average sound levels underlining that in terms of aircraft noise the average noise indices cannot describe with accuracy the role of events in the perception of environmental noise and possible annoyance.



Figures 5. Strategic Noise Map of the subarea -L_{den}

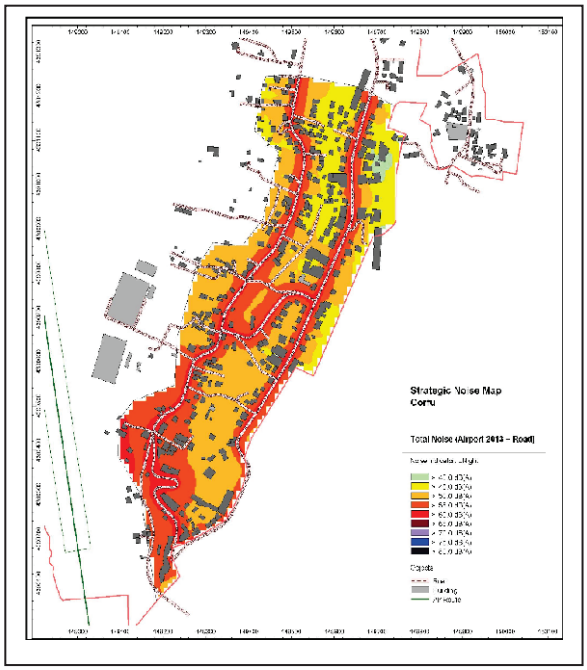


Figure 6. Strategic Noise Map of the subarea -L_{night}

2.3 Interviews analysis

2.3.1. Interviewed people composition

Interviewed people panel can be described as follows:

- Tourists (92%) as well as Greeks (25%) and foreigners (72%). Mostly from organized groups from Europe, mostly from Germany, France United Kingdom, but also from Switzerland, Austria and from the Netherlands.
- Some employees in the touristic activities and infrastructure (8%) and
- Some permanent residents (3%).

Various professional categories were represented in the sample: employees (35%), freelance (38%), retired (13%), unemployed (7%), public services (6%), students (4%).

2.3.2 Analysis of the answers of the questionnaire

When people was asked how they feel in the subarea (1 for town and 7 for the sea front), a majority of them quoted that they're close to the sea. Is obvious that the natural dimensions of the site (trees, vegetation, proximity of the sea) characterize the perception of tourists. However some of them, due to the proximity of the subarea to airport infrastructures and to the city centre, they consider it as part of the city. On the question on the influence of the road traffic in the place where they stay or work, the population surveyed overwhelmingly said not to be disturbed: values 6 and 7 (not at all) on the given scale represent more than 80% of the answers). On the issue of neighbourhood sounds, if the sounds are representative of a dynamic and vivid sound environment and or boring one, respondents are divided into 2 categories. One that believes that it is the expression of a living environment (response options 1, 2 and 3) and another one that thinks that this can be annoying (answer choice 7).

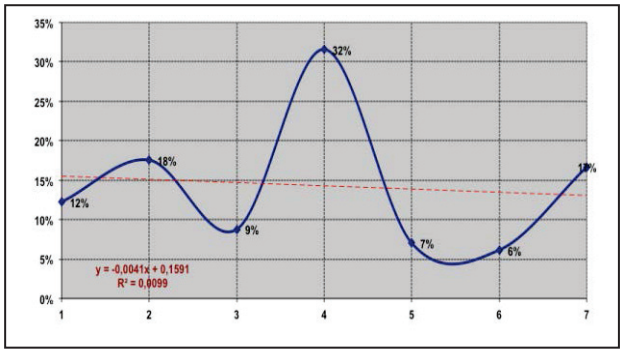


Figure 7. Distribution of responses to question 3: *"Can you hear the sounds of the neighborhood here? How would you evaluate it? (on a scale from 1 'vivid' to 7 'disturbing')*

Looking in detail what one perceives when listening to the sound environment, it is very clear that the vast majority hears the take-off and landing of the aircrafts. This response is particularly present for the vast majority of interviews conducted in areas overlooking the airport runways. Practically all people were there for the obvious reason to enjoy the views and the experience of operating aircrafts in proximity. The graph in fig.8, shows that over 57% of respondents consider the sounds of airplanes is the most characteristic sound of this area.

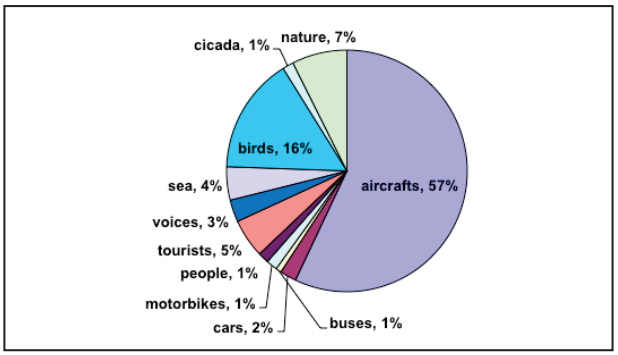


Figure 8. Answers distribution to question 6: *"Which sounds mark the place where we're now ?"*

Furthermore based on the statistical analysis we underline that:

- Interviewees largely quote nature either in its generic sense ('the nature') either by describing specific sounds like birdsongs and crickets.
- is rather surprising that, on the airport observation sites, objectively ones can hear more sounds from human activities than from aircraft operations e.g. music in cafes, discussions, arrival and departure of tourist groups, etc.. These sounds marking the identity of the subarea are clearly mentioned in the answers, however on a relatively low level compared to airport events.

The airport is omnipresent in the minds of listeners and it is obviously quoted as the main source of annoyance as per the relevant graph hereafter.

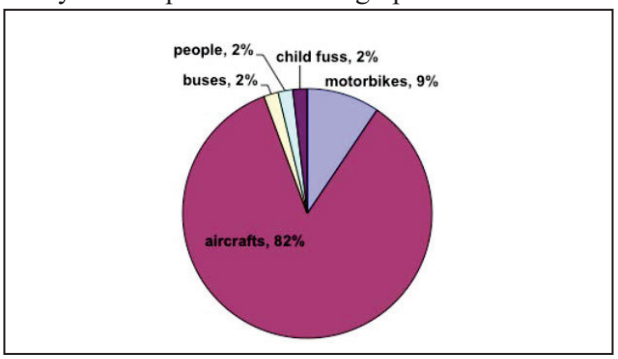


Figure 9. Answers distribution to question 7: *"Which ones are disturbing?"*

Interviewed people consider that quietness can be found everywhere (67%) in studied area and for some of them within the east sides. Although Canoni area is considered as quiet even if is in close proximity and in direct view with the airport. Regarding nightlife noise (amplified music, car and powered two wheels - PTW, conversations, road traffic etc.), we need to underline that the majority of respondents did not witness any particular problem (75% said no, 4% rarely and 14% somewhat). Regarding the airport operation the

answers were clear enough with the respondents stating that they can hear both arrivals and departures of aircrafts (66%), with some of them due to their place of residence stating hearing only the departures (26%) of some them not hearing anything (8%) (see fig10).

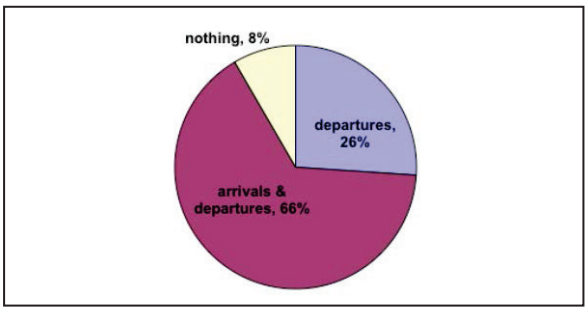


Figure 10. Answers distribution to question 16: *"Can you describe to me **what** do you hear from the airport "*

These events are most pregnant in summer time than in winter time and appear to be constant regardless of the time of day with some people stating that they are more intense during the day especially coming from people working on site (working hours) – see fig11.

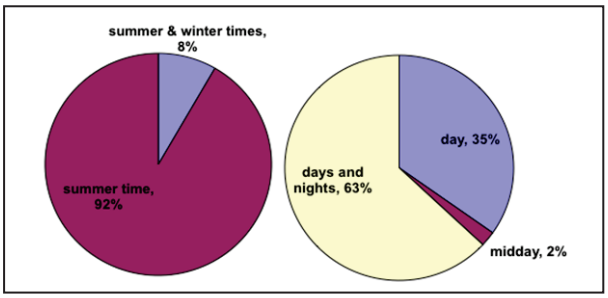


Figure 11. Answers distribution to question 16: *"Can you describe to me **when** do you hear the airplanes "*

Although approximately 18% of interviewees considered aircraft operation as a source of annoyance (answers 1, 2 and 3 combined). Actually, the vast majority think the opposite (68%). People come to Kanoni near the airport in order to see and hear the aircrafts, not disturbed by the noise. It should be noted that a 58% of the interviewees have their residence facing towards the airport (the remaining 42% state no). One may ask whether this perception is uniform no matter the location of interviewees. Therefore we have re-divided the sample according to four major hotels in the area where respondents lived or worked. Our panel is presented as follows: From a general point of view, the 4 hotels offer a similar distribution of responses that is to say (see fig 12.):

- whatever the hotel location, most respondents can hear both arrivals and departures of aircraft.
- whatever the hotel, a smaller number of people hears only the departure of aircraft, representing 7 - 8% of respondents expressed for hotels Corfu Holidays Palace Hotel Divani Palace Hotel and Royal Boutique Hotel. This rate drops to 3% for residents of the hotel Areti. A cross of the replies shows that this does not necessarily correspond to those who rent a room that has a view of the airport. We can still make the assumption that the orientations of hotels Areti and Corfu Palace is partly favourable to the protection of some rooms from the noise of the airport.
- The hotel Areti and Corfu Hotel Palace are the one that presents few responses from people who say they hear nothing about the airplanes arrivals and departures.

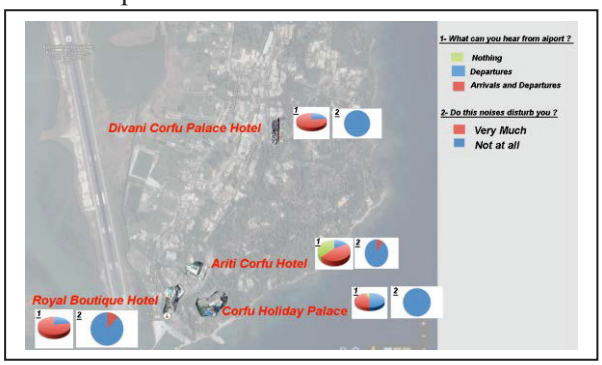


Figure 12. Aanswers distribution to question 16 sorted by hotels: *"What can you hear from the airport ? and Do this noises disturb you ?"*

3. Discussion

Because of its location, the international Aiport of Corfu Island do not present so much annoyance to tourists and residents. Actually, at the opposite, touristic establishments as hotel and coffees place use it as a recreative issue. The low density of the builts spaces, the feeling of nature on site, the proximity of the sea are indexes that mark the tourists perception. As long as Airport activities keep its ways of functioning, in situ measurements, and simulations have shown the limited noise annoyance level introduced to the population.

References

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[4] **Vogiatzis K**. and **Remy, N**., *Strategic noise Mapping of Herakleion: the aircraft noise impact as a factor of the International Airport relocation*, in Noise Mapping Journal, 2014, 1:15-31 p.